6 SERVICE AND TROUBLESHOOTING

6.1 General service information

Usually field service is limited to swapping the faulty circuit boards or mechanical parts. The boards are then returned to DATEX-ENGSTROM for repair.

CAUTION: The measuring units ACX-100/200 can only be repaired and calibrated at DATEX-ENGSTROM.

CAUTION: The agent identification benches ASX-100/200 can only be repaired and calibrated at DATEX-ENGSTROM. If the motor assembly, preamplifier board, EEPROM, temperature measuring components or the reflectance sensor A1 have failed the unit must be repaired and recalibrated at factory. Temperature compensations and temperature zero can only be calibrated at factory.

DATEX-ENGSTROM is always available for service advice. Please provide the unit serial number, full type designation, program revision (displayed at monitor start-up) and a detailed fault description.

NOTE: After any component replacements see Section 7.1 and after any service perform the functional field check procedure in Chapter 8.

CAUTION: The tests and repairs outlined in this section should only be attempted by trained personnel with the appropriate equipment. Unauthorized service may void warranty of the unit.

6.2 Disassembly and reassembly

The CAPNOMAC ULTIMA™ is disassembled in the following way (see Figure 9.1 for the exploded view of the monitor):

a) Disconnect the power cord.

b) Remove the upper two galvanized screws on the side panels and lift off the top cover.

c) Remove the lower two screws and detach the side panels.

Now the interior of the monitor is exposed.

> **CAUTION:** The special internal sample tube is mechanically fragile. Sharp bends will cause leaks.

d) Keyboard pc board with plastic key panel is attached closely to the front plate.

e) SpO_2 measuring board is attached to the front panel with 6 cm long bushing and cotter.

f) Four boards are attached to the horizontally positioned mother board in the center: (from f to r) PVX board, ACX measuring board, CPU board, and video control board. These boards are removed by pulling upwards.

Beneath the mother board the intermediary bottom plate houses O_2 measuring unit, pump, some constriction cassettes, and gas sampling system parts.

ASX agent identification unit is attached to the bottom plate in upright position on the left side of the picture tube.

g) Power supply board is attached to the rear plate with five screws.

h) ACX photometer which holds preamplifier board, transformer, power cord receptacle block, loudspeaker, fan and dust filter, flow constriction cassette, fuse housing(s) and sample gas out connector are all attached to the rear panel with screws.

The rear panel can be tilted back by first detaching the switch cable from the power cord receptacle block and removing the two screws beside the fan which are keeping the rear panel in the upright position and sliding the panel in sideways.

i) The main pc board for the picture tube is attached to the bottom plate with bushings.

Two magnetic valves, damping chamber, and the intermediary bottom plate assembly are screwed to the bottom plate.

The picture tube unit is screwed to the front plate.

Most parts can be removed by loosening the appropriate screws.

j) Reassembling is essentially reversing what was described above.

CAUTION: When attaching the top cover, make sure that the tubes and cables are not pinched between the boards and the cover.

6.3 Service menu

In Service menu you can perform simple checks to troubleshoot the monitor.

Enter the Service menu by pressing down any key except the soft key 4 during selftest and then pressing the soft key 3.

The Service menu consists of five services: Gas service, SpO_2 service, Error list, Factory reset, PVX service and ASX service. Enter by pressing the key indicated on the screen.

6.3.1 Gas service

a) Momentary, ET-, and Fi-values of each gas are displayed in %-unit along with working pressure inside the monitor (PRE).

b) Pump, pressure valve, and zero valve are operated manually with the number keys (1, 2, 3).

c) Calibration constants of zero and gain for each gas are displayed. The constants are according to the ACX measuring chamber. The zero constants will change at gas zeroing.

When the monitor performs gas zeroing, the main software will write new zero constants for the gases (CO_2, N_2O, AA, O_2) to the ACX memory. If some dust (or water) has entered the measuring chamber, zeroing of the gases require higher zero constants than before depending on the contamination level. If some gas requires higher value than 65536 the unit is not able to perform the zeroing and the message "XXX ZERO ERROR" appears to the error list and the software recalls the previous zero constant for the concerned gas. If this happens at the initial start up the software will not pass the "calibrating gas sensor" state.

The N_2O zero point is very sensitive for the measuring chamber contamination. Therefore the zero constant of N_2O can be utilized in observing the contamination level of the ACX measuring chamber. The optimum value for the N2O zero constant with new and clean measuring chamber is 45000 indicating the ratio of 1:1 between the measuring and reference channel signals. The maximum acceptable value for the N2O zero constant is 51000 for a new measuring unit. The maximum value that the main software is able to set is 65536.

Ambient pressure is also displayed.

d) Gas fall times are calculated automatically with the 4 key (see Response time test in section 6.4.3 Gas sampling system troubleshooting).

When ASX-200 is installed, go to ASX service first to get the bench zeroed.

Response time difference between gases is displayed as "DIFF".

The fall times and time differences reflect the condition of the D-FEND™ water trap filter. The maximum allowed times are as follows:

CO_2 ASX delay	1500 ms (with ASX-200)
CO_2 fall time	360 ms
O_2 fall time	480 ms
AA fall time	520 ms
N_2O fall time	360 ms
CO_2 O_2 diff	1400 ms
CO_2 AA diff	160 ms
CO_2 N_2O diff	100 ms

Return to the previous stage by pressing the NORMAL SCREEN key.

6.3.2 SpO_2 service

In SpO_2 service the following parameters and their values are displayed.

PARAMETER	EXPLANATION
Vred	Red channel voltage. About 10 V when probe is attached and pox dac gain is high enough. 0 V without probe.
Vrac	Red channel amplified alternating component. It has a waveform similar to the pleth waveform.
5Vr	Red channel 5 V.
GNDr	Red channel ground.
Vrc	Same as "GNDr" with probe. Same as "5Vr" without probe.
Vired	Infrared channel voltage. About 10 V when probe is attached and pox dac gain is high enough. 0 V without probe.
Virac	Infrared channel amplified alternating component. It has a waveform similar to the pleth waveform.
5Vir	Infrared channel 5 V.
GNDir	Infrared channel ground.
[..] voltage to pin 22	Repeat pressing the 1 key to have the desired voltage at pin 22 of the rear panel serial/analog I/O connector.
led intensity HIGH/LOW	The intensity is changed by pressing the key 3.
pox dac gain	The state of the SpO_2 measuring board D/A converter data lines in binary format. The data line is changed by pressing the key 4.

Return to the previous stage by pressing the NORMAL SCREEN key.

6.3.3 Error list

1. ERROR LIST

The last twenty errors are listed with the time and date of the occurrences. See the following table for possible messages, their causes and further measures.

1. CO2 zero error
2. O2 zero error
3. N2O zero error
4. AA zero error

Items 1 to 4. Ultima does not manage to zero ACX. If the message appears occasionally (even once a day), it's OK. When the zeroing fails Ultima uses the previous zero value as the new value. Even a small noise in the ACX bench may cause zero error.

6. Continuous occlusion

Check D-fend. If the message appears sporadically, there is no need to take any action.

9. EEPROM failed (EEPROM to defaults)

EEPROM failure. Check CPU board. Change the board if necessary.

10. EXTERNAL RAM error

Check CPU board. RAM read/write failure. Change the component.

11. ROM checksum error

Check CPU board. EPROM read error. Change the component.

12. POX downloaded

POX board faulty and the measurement is adjourned.

17. ACX sampling system error

AA, N2O, and CO2 measurement voltage drifted out of $\pm$8 V range. May appear only after initialization. If appears occasionally (even once a day), it's OK. The reason may be tubing system error or valve error. If appears often, the ACX bench may be faulty.

18. ACX synchronizing pulse error
19. ACX chopper motor error

Items 18 and 19. Synchronization error. Change the ACX bench.

20. ACX pressure sensor error

The pressure exceeds 400 to 900 mmHg range. May appear during initialization. May indicate faulty pressure parameters in ACX measuring board EEPROM, which requires factory calibration.

Erroneous pressure value corrupts pressure compensation of all gas values.

21. Continuous air leak
Like item 6, if the message persists, check the sampling system and fix the leak.

25. ACX internal RAM error
26. ACX ROM checksum error
27. ACX external RAM error
Items 25 to 27. Change the component. See the items 9, 10, and 11 above for references.

28. Error in meas. board EEPROM
29. Error in preamplifier board EEPROM
Items 28 and 29. Change the meas. board or the ACX bench.

30. ACX AGC error
AGC gain control error for each gas in ACX measuring board. Possible reasons for this message are: 1. contaminated bench 2. gas concentration higher than room air level during initialization 3. lamp voltage too low

31. ACX ADC error
Can appear occasionally with the item 17 "ACX sampling system error" and it's OK. If appears WITHOUT the item 17, it means HW malfunction. Caused by too long AD conversion time. Check ACX measuring board ADC section.

32. ACX DAC error
Reference voltage adjustment error for CO2 and AA.

36. ASX TEMP OUT OF RANGE
ASX is beyond the temp specification range (5 to 60 degrees centigrade). ASX may be too cold. Warm it and try again. Temperature sensor may be faulty.

41. ASX AGC VOLT CLAMP ERROR
Automatic gain control failed. Signal out of range. If this message appears only after power-on and not continuously, the situation does not require any action.

42. ASX MOTOR LAPTIME ERROR
Motor speed has fluctuated. Just as item 41.

43. ASX EEPROM OUT OF LIMITS
EEPROM contents are false. If appears often, change the ASX unit.

44. ASX EEPROM WRITE ERROR
Write to EEPROM not succeeded. If appears often, change the ASX unit.

45. ASX ROM CHECKSUM ERROR
EPROM contents are false. Change the component.

46. ASX AUX RAM ERROR
Auxiliary RAM failed. Change the component.

50. PVX reset
51. NO RESPONSE FROM PVX
56. PVX DOWNLOADED
Items 50, 51 and 56. The message "NO RESPONSE..." appears when Ultima loses PVX. Then "PVX reset" follows and finally "PVX downloaded" and the measurement is cancelled.

Those messages may appear because of occasional serial communication fault and may not mean anything serious.

52. ULT -> PVX CSUM ERROR
53. PVX -> ULT CSUM ERROR
Items 52 and 53. Serial communication between the two of them failed. Quite rare and can appear for an elusive reason.

54. COMMAND NOT IMPLEMENTED
Ultima is sending wrong commands which PVX cannot recognize.

55. WRONG RESPONSE FROM PVX
PVX is giving wrong response to Ultima. PVX faulty.

58. ASX reset
ASX reinitialized. Reinitialization is always done once after an error message comes from ASX. If the error persists ASX is downloaded.

59. NO RESPONSE FROM ASX
Ultima does not communicate with ASX. Bench disconnected or faulty.

60. ULT -> ASX CSUM ERROR
61. ASX -> ULT CSUM ERROR
Items 60 and 61. False string in communication. See the items 52 and 53 above.

62. COMMAND NOT IMPLEMENTED
63. WRONG RESPONSE FROM ASX
64. ASX DOWNLOADED
Items 62 to 64. Communication with ASX stopped because of errors. ASX INOPERATIVE-message appears on Ultima. See the items 54 to 56 above.

2. DATE SET

Choose DATE SET with the 4 key. Set the day (dd), month (mm), and year (yy) correct. Press the RIGHT key to accept the number and move to the next item.

Return to the previous stage by pressing the NORMAL SCREEN key.

6.3.4 Factory reset

You should perform the factory reset if:

- you have changed the software EPROM.
- you have changed CPU board or the EEPROM chip on the CPU board.

Activate factory reset by pressing the 2 key (yes). After the reset all settings and calibration values are replaced by factory set values and error list memory is cleared. Before returning to monitoring perform gas calibration.

6.3.5 PVX service

In PVX service the following parameters and their values are displayed.

Only the parameters marked with '*' are allowed to be adjusted. To adjust, first move box with the NEXT key to the parameter. Then increase or decrease the value with the arrow keys. Press the SAVE key to validate the change.

PARAMETER	*EXPLANATION*
Pres Awp	Overpressure or negative pressure in the airway at that moment is displayed in cmH_2O. Display range $\pm$99.9 cmH_2O.
Pres Min, Pres Max	Minimum and maximum pressure is displayed. Display range $\pm$99.9 cmH_2O.
Flow0	Average value of eight samples of A/D converted Flow0 signals. The number 0 corresponds to -10 V, 2048 corresponds to 0 V, and 4095 corresponds to +10 V.
Flow1	Value of Flow0 amplified by 11.
Flow	Flow is displayed multiplied by 100. Gas density compensation is done in addition to pressure and temperature compensations. The range $\pm$12000 corresponds to flow $\pm$120.00 l/min.
Flow Volt	Value of Flow0 after pressure and temperature compensations is displayed. Display range 0 to 4095.
Vol Exp/Vol Insp	Volumes of expired/inspired gas are displayed in ml unit. Display range 0 to 3200 ml.
Vol Min Exp/Vol Min Insp	Volumes of minute expired/inspired gases are displayed. Display range 0 to 99.99 l/min. Note that decimal dot is not displayed (3450 l/min actually means 34.50 l/min).
Pres Zero*	Value of Pres Awp can be adjusted to zero by changing Pres Zero value. Range of Pres Zero is 1000 to 2400.
Pres Gain	Gain of pressure measurement is displayed. This value should be 8662.
Flow Offset Adj*	Voltage of DAC3 (A8 pin 14) adjusted. DAC3 cancels the offset of pressure transducer B3. Number 0 corresponds to 0 V and 4095 corresponds to +10 V. Value of Flow can be adjusted to zero with this adjustment. Range of Flow offset adjustment is 100 to 4000.
Insp Gain*	Gain of inspired gas volume. Usually the value is between 5000 and 9000.

Exp Gain*	Gain of expired gas volume. Usually the value is between 5000 and 9000.
Common Offset	Cancels common error which is caused by pressure from the pressure transducers. This is a transducer's own constant. The common offset should be between -230 and +230.
Flow Offset	Not used.
P T corr	Not used.
Temp Gain	Not used.
Rel Hum*	Humidity of inspired gas in %-unit.
Cal Temp*	Temperature of inspired gas in degrees centigrade.
Valves*	Can operate zero valves manually.

When Valves is in ON position, check the following items:

a) that the Pres Awp value is between -0.1 and +0.1, and it can be adjusted by Pres Zero.

b) that the Flow0 value is between 2046 and 2050, and it can be adjusted by Flow Offset Adj.

c) that the Flow Volt value is also between 2046 and 2050, and it can be adjusted by Flow Offset Adj.

d) When the Valves is in ON position, those readings should not change even if pumped by calibration pump

e) Return to the previous stage by pressing the NORMAL SCREEN key.

NOTE: Do not leave the Valves in ON position for more than one hour.

6.3.6 ASX service

ASX is automatically zeroed after entering the menu. Let the unit warm up 30 minutes before calibrating ASX.

SOFTKEYS

SPECTR ON/OFF

ON displays the measured spectrum. OFF gives faster response on other measurements.

ZERO & CAL

Measure background and calibrate timeoffset and lambda0.

FILTER ON/OFF

Software filtering ON or OFF. ON is the normal setting for measurement. OFF is used only for noise measurement.

SELECT SQERR

Selects the agent FREON/HAL/ENF/ISO/DES/SEV. The squared error of the selected gas is calculated against the corresponding reference spectrum and displayed.

PARAMETER	EXPLANATION	*LIMITS*
Ident.	Gives the identified gas or mixture (HAL/ENF/ISO/DES/SE V CAL.GAS/MIX)	
Conc./Total conc %	Concentration measured by ASX. NOTE! For Datex calibration gas the value is the concentration of cal. gas.	
Proportions (rel%) (ASX-200 only)	The relative proportions of each agent in total concentration.	*Cal. gas > 70, other agents > 85 for a pure agent*
Alcohol	Measured alcohol concentration.	
Noise	SD-noise. NOTE! Interpret the value only when no gas is fed, FILTER is OFF and after a minimum of one minute stabilization time.	*< 80*
Peak norm. and Peak mirr.	Give the place of the peak of spectrum in channel numbers.	
AGC	Automatic gain control. Range 0 to 4095. Check lamp when 4095 is displayed.	*100 to 3500*
Temp	The temperature inside ASX bench.	
MOTOR Fluct.	Motor speed fluctuation.	*<200*
MOTOR DAC:	Motor speed control voltage 0 to 4095.	*100 to 3900*
MOTOR Lap time	Should be 30000	
SQerror	Squared error.	*R23 < 400* (ASX-100 only).

CALIBRATION VALUES

FACT. column shows the initial factory calibrations.
EEPROM column shows the values that are currently used by the bench.
CALIBR. column shows the values after calibration before they are stored to EEPROM.

Time offset	Time between sync pulse and measured spectrum. 30000 corresponds to 360° or 40 ms.

CALIBRATION

The time between synchronization pulse and measured spectrum (time offset) of the ASX-100/200 is calibrated together with the gas calibration of the ACX.

a) Press ZERO&CAL to start calibration. Zeroing is done first.

b) Feed cal.gas until TIME OFFSET is OK.

c) EEPROM column shows the previous calibrations and CALIBR. column gives the values measured at the previous calibration. Time offset should not change more than 15. If the change is bigger, restart from the beginning.

d) Exit the calibration menu with "STORE TOFFS" softkey to store Timeoffset.

e) Feed cal. gas until values are stabilized and check that both peak channels show the same values within 0.15 (ASX-100) or 0.3 (ASX-200). If not, perform gas calibration again.

6.4 Troubleshooting

6.4.1 Monitor start-up sequence

After the monitor is switched on or reset

- Fan on the rear panel starts to run.
- Pump starts and zero valve opens. Measuring of zero levels for each gas starts.
- Shortly Selftest text appears on the screen. All the memory in the monitor is checked. Program code and the date of its completion are also displayed.
- Within a half minute fields for waveforms and numeric values will appear. No waveforms or data are displayed yet. The message "CALIBRATING GAS SENSOR" indicates that the measuring of the zero levels is in progress.
- Pump stops for 30 seconds for checking atmospheric pressure.
- Pump restarts and zero valve closes for checking working pressure.

  Program sets initial occlusion and air leak limits. The monitor is now ready for use.
- Waveforms and numerical data appear on the screen. The message "CALIBRATING GAS SENSOR" disappears.
- Pressure valve opens for measuring pressure difference between IN and REF flow pressures of the oxygen measuring unit.
- Pressure valve closes.
- After 5 minutes since the first zero level measurement, the zero valve opens for a moment to check the zero level automatically. During the zero level checking (zeroing) the screen is frozen.
- After the zeroing the pressure valve opens for a moment for the pressure difference measurement.
- The next automatic zeroing is then performed every five minutes during the first 30 minutes. Every 15 minutes during the next 30 minutes and once in 30 minutes thereafter. The zeroing is always accompanied with the pressure difference measurement.

6.4.2 Troubleshooting in general

> **NOTE:** Please read "Troubleshooting and Displayed Messages" in the Operator's Manual first. The part of this chart is duplicated from it.

Table 6.1 General troubleshooting chart

TROUBLE	POSSIBLE CAUSE/REMEDY
No response when power is turned on	Power cord disconnected or not connected properly. Fuse blown. If they get blown repeatedly, go on to the electronics troubleshooting.
No picture	The primary, secondary or video fuse possibly blown. The CPU board or the power supply board faulty. If the keyboard response beep is heard, probably the video control board or CRT unit is faulty.
No response to breathing	Sampling line or water trap blocked or loose, or improperly attached. Water trap container full. If the trouble persists go on to the following troubleshooting sections.
EXTERNAL RAM ERROR-message	Check CPU board; RAM read/write problem. (This message possibly appears in start-up). Go on to the following electronics troubleshooting sections.
ROM CHECKSUM ERROR-message	Check CPU board; EPROM read error. (This message possibly appears in start-up). Go on to the following electronics troubleshooting sections.
LOW PLETH SIGNAL-message	The signal quality is poor and the measurement may be inaccurate. Probably no equipment malfunction. (Often occurs in patients with low perfusion).
ARTIFACT-message	There is a very strong occasional AC component in the measured pleth signal. (Probably because of patient movement or vibration).
xx ZEROING ERROR-message	Gas zeroing failed. Condensation or residual gases are affecting zero measurement. Allow monitor to run drawing room air for half an hour and calibrate again. If it does not help, go on to the following troubleshooting sections.
MEMORY CHIP FAILURE-message	+5 V supply voltage is too low (< 4.75V). Check +5 V. Internal battery in SRAM (D4) on High Speed CPU board is flat. Replace D4.

(continues)

AIR LEAK-message	Air leak in sampling system. Probably water trap or the sampling line is not attached properly. Gas zero valve failure. Pump failure or gas outlet blockage. If Return Gas Kit is used, check the bacteria filter.
REPLACE TRAP-message	Flow resistance increased due to residue build-up on water trap membrane. Change the water trap.
REBREATHING-message	CO_2 concentration in inspiratory air is too high. Possibly CO_2 absorber in ventilator is saturated. Change the absorber.
OCCLUSION-message	Sampling line or water trap is occluded. Water trap container is full. If occlusion persists check internal tubing for blockages.
SELECT AGENT-message	No anaesthetic agent is selected though delivery is started. Vaporizer valve is broken. Traces of cleaning or disinfecting agent in the water trap container affecting the readouts. Let the container dry properly after disinfection before use.
Bad or missing SpO_2 waveform and reading	Faulty SpO_2 probe. If not, faulty SpO_2 measuring board.
NO PROBE-message	No probe connected to the monitor. Probe faulty. Check probe connections.
PROBE OFF-message though probe properly attached to the patient	Unsuitable site. Try different site. Probe faulty.
CHECK PROBE-message	An appropriate DC level has not been found in probe signal. (Possibly because of LED in probe failure). Change the probe.
OBSTRUCTION-message	Obstruction in double lumen tube, ventilator tubes, or patient airways. Check those tubes.
DISCONNECTION-message	Ventilator tubes or D-LITE™ disconnected. Check the connection. Ventilator valves malfunctioning. Check the ventilator.
LEAK-message	Airway tubes or ventilator tubes leaking. Ventilator valves malfunctioning. Check the tubes and valves.

6.4.3 Gas sampling system troubleshooting

The faults which can occur in the sampling system are: leaks or blockages in the tubing, failure of the sampling pump or the magnetic valves, or diminishing of the flow rates because of pump aging or dirt accumulating in the internal tubing. The troubleshooting chart of the sampling system is shown in Figure 6.1.

The following checks should help in localizing the fault. Whenever suspecting the sampling system and always after having done any work on the sampling system check and if necessary adjust the flow rates.

The sampling system details are illustrated in Figures 5.2 and described in Tables 5.1 and 5.2.

NOTE: DATEX-ENGSTROM D-FEND™ water trap should be changed when the occlusion alarm comes on during the monitor start-up sequence in normal use.

CAUTION: The special internal sample tube is mechanically fragile. Sharp bends will cause leaks.

NOTE: If the ACX-100 measuring unit has got liquid inside the measuring bench due to water trap filter failure, contact DATEX-ENGSTROM Technical Service.

Connect power cord and sampling line. Turn the power on and wait until the initialization is over. Set the real time correct in SET-UP Monitor menu.

1. SAMPLING SYSTEM LEAK TEST

Keep pressing the MARK key and enter the Installation menu. Choose Service menu and wait until the initialization is over.

Choose GAS SERVICE. Connect a tube to the sample out connector and drop its other end into a glass of water.

Block the sample inlet, reference flow of the oxygen measuring unit, and the upper tube in CO_2 absorber. Wait for one minute.

There should be less than 1 bubble per 10 seconds coming out of the tube. Bubble should not move upwards more than 11 mm per 30 seconds inside the tube. If it does, there is a leak between the pump and the sample out connector.

Perform leak test to the CO_2 absorber by opening zero valve with the 3 key. The maximum permitted leakage is the same as above.

CAUTION: Do not turn the pump off while performing the leak test. Negative pressure in the sampling system will suck in water in the glass.

2. WATER SEPARATION

Dip the patient end of the sampling line into water quickly (about half a second) three times at 45 seconds' interval. After that drop the end into water and lift it up when the sampling line is totally filled with water.

Check that all the water goes into the trap container and not into the monitor.

3. STEAM TEST FOR THE SPECIAL TUBE

Choose halothane as anaesthetic agent and let the monitor sample room air. Then quickly feed air of 100 % relative humidity (for instance from a kettle in which you have boiling water) to the monitor. If the digital reading jumps as much as 0.1 % then replace the special tube.

4. RESPONSE TIME

Choose Service menu and then GAS SERVICE. Feed test gas until the gas value on the screen remains stable. Press the 4 key and pull the sampling line quickly out of the gas source. The monitor calculates the fall times automatically and shows the values on the right-lower side of the screen. The maximum allowed fall times are:

CO_2	360 ms
O_2	480 ms

If the response time is slow, change the water trap. Return to Service menu by the NORMAL SCREEN key.

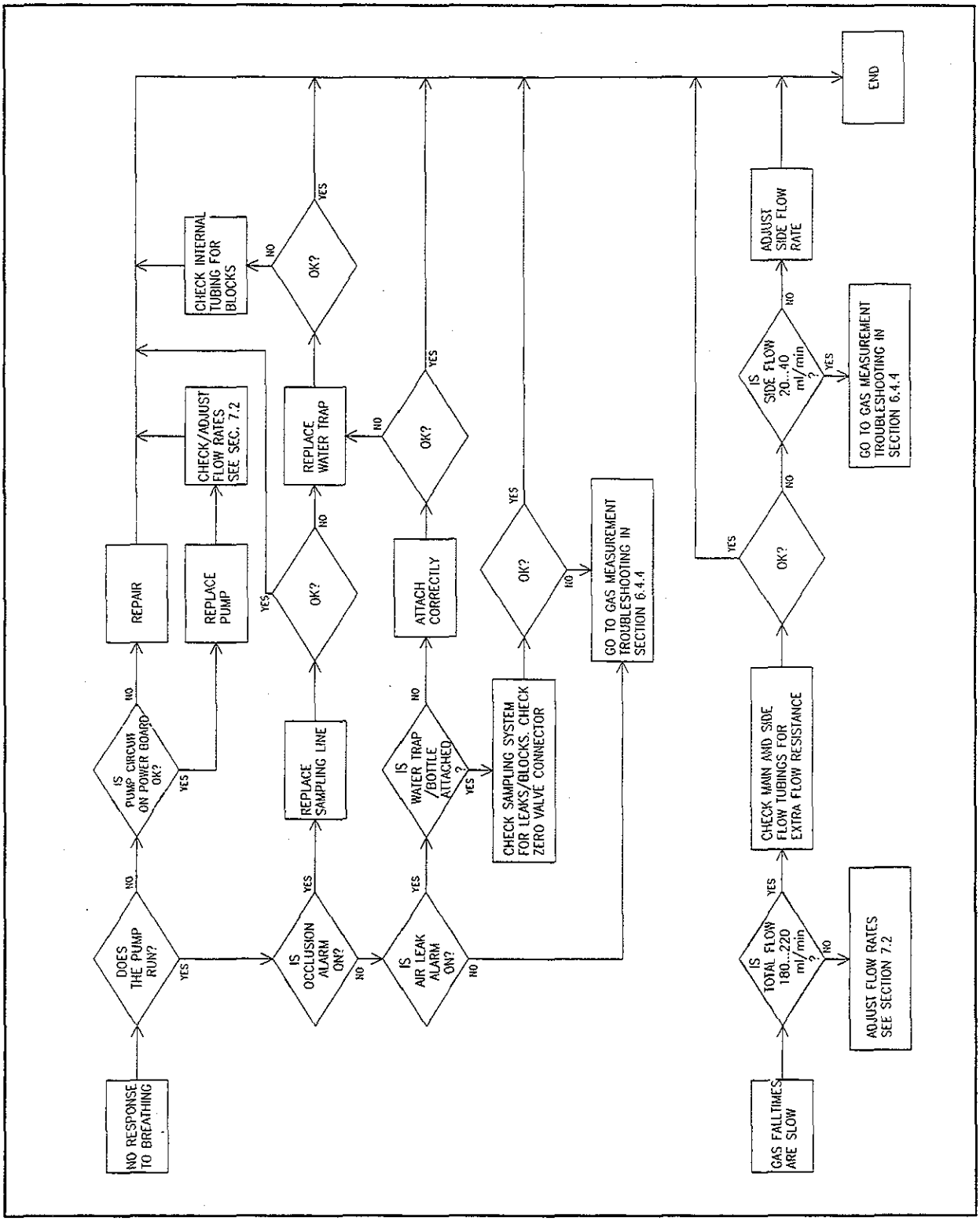


Figure 6.1 Gas sampling system troubleshooting chart

6.4.4 Gas measurement troubleshooting

Table 6.2 Gas sampling system troubleshooting chart

SYMPTOM	POSSIBLE CAUSE/REMEDY
No response to any gas	Sampling line or water trap blocked. Internal tubing (constriction cassettes) blocked or loose. Water container loose. Pressure valve malfunction. Pump failure. Supply voltage missing (power supply board failure) A/D converter faulty.
No response to neither CO_2, N_2O nor AA	Chopper motor not running. IR lamp failure. Check the IR lamp resistance (approximately 3.5 Ohm) and the lamp voltage (4 VDC min). If there is no voltage, check the LAMP ON signal from the ACX measuring board (connector X1 pin b13). If the line is high the mosfet V7 on power supply board is faulty, if low, the chopper motor is probably stalled. Check for timing pulses from the preamplifier board. AGC amsrplifier (A4) faulty. Coarsely erroneous or missing reference voltage. Timing pulses missing.
Either CO_2, N_2O or AA response missing	Analog switch faulty or control pulses missing. Other components fault in the measuring electronics. Check by following the signal with an oscilloscope along the amplifier chain.
No O_2 response	O_2 measuring unit tubes loose or blocked. O_2 measuring unit connecting cable loose or faulty. O_2 measuring unit internal tubings blocked by water. Disconnect O_2 measuring unit tubings and try to remove water by pumping air into the connector "OUT". O_2 measuring unit faulty. Replace. Analog multiplexer faulty.
Zeroing of CO_2 N_2O and/or AA fails	Measuring bench contamination. Replace ACX measuring unit or try to clean the measuring chamber as per instructions 6.4.13.
Strong drift in all gases	Leak in sampling line or internal tubing (especially in conjunction with too low readings). AGC malfunction. Check analog switches and control pulses.

(Continues)

Strong drift of CO_2, N_2O and AA	Fluid or dust in measuring bench. Electrical connections to IR lamp faulty. Loose screws in measuring unit. AGC circuit faulty (ACX measuring board).
Strong drift of O_2	Blocked O_2 reference flow. Uneven sample pump function. Replace pump.
Sudden increase in gas display	Measuring cgamber contamination. +/-15 V missing (fault in the power supply).
The above occurs frequently	Water trap malfunction. Check all internal tubing and the interior of the water trap for occlusions or leaks. Replace water trap. Check flow rates.
$CO_2/N_2O/AA$ software calibration fails	Analog gains out of range. Check the general functioning of the measuring electronics.
O_2 software calibration failure	Adjust the gain trimmer of O_2 measuring unit. If not possible, replace the measuring unit.
'Calibrating gas sensor' -message remains on the screen	CO_2/N_2O gas analog voltages out of range (over about 9 V). Measuring chamber contamination or failure on measuring unit electronics or on measuring board.
Impossible to adjust gain	AGC malfunction. Check analog switches and A4. False reference voltage. Faulty temperature compensation circuit.
Too low response in both CO_2, N_2O, and AA (and possibly O_2)	Leak in water trap, or tubing between the trap and the measuring units; the sample is diluted with air.
Abnormally high response to all gases (or abnormally low) or sudden occlusion warning	Pressure transducer failure on ACX measuring board (check Pout voltage).
Random output (resembling noise)	Timing pulses out of sync. Check timing pulses from photometer, pulse shaping circuit, and logic circuitry on the measuring board. Chopper motor not running Motor faulty or connection loose. Driver transistor C-E open circuit or current limiter short circuit.

6.4.5 O_2 measurement troubleshooting

Because of the complex and very sensitive construction of the oxygen measuring unit no repairs should be attempted inside the unit. Instead, if the fault has been found in the measuring unit itself, it should be replaced and the faulty unit be sent to DATEX-ENGSTROM for repair.

In case of no response to O_2 or strong drift, check the tubing for loose connections, blockages and leaks.

> **CAUTION:** Never apply an overpressure to the O_2 measuring unit as the pressure transducer may be permanently damaged.

If O_2 zero error message is displayed check the O_2 measuring unit output voltage at pin 13 of connector X13 on the mother board (see Section 7.3.1).

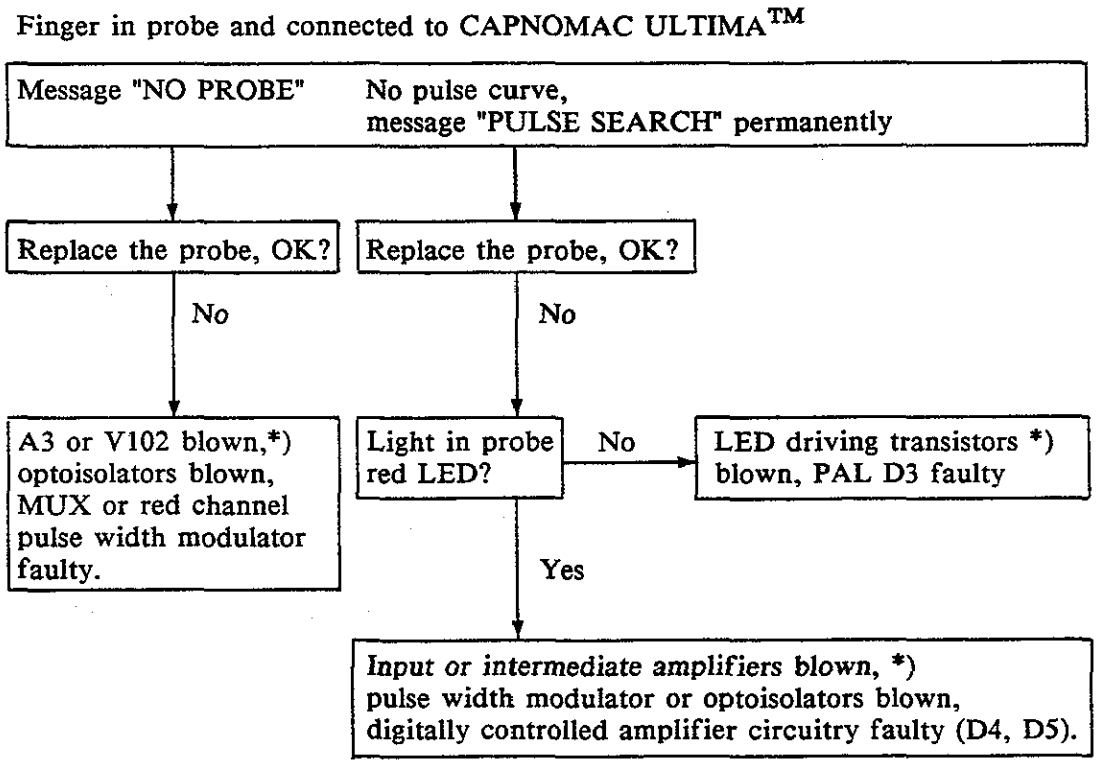
If the adjustment range of the (software) calibration is insufficient check the O_2 measuring unit output voltage and adjust the gain if necessary (see Section 7.3.2).

If there are problems with O_2 response time check the O_2 measurement flow rate and adjust it if necessary (see Section 7.2).

If the O_2 signal is noisy, check the measurement unit suspension.

6.4.6 SpO_2 measuring electronics troubleshooting (ULT-S model);

Figure 6.2 SpO_2 measuring electronics troubleshooting chart


Finger in probe and connected to CAPNOMAC ULTIMA™
Message "NO PROBE"
No pulse curve, message "PULSE SEARCH" permanently
Replace the probe, OK?
Replace the probe, OK?
No
No
A3 or V102 blown,*) optoisolators blown, MUX or red channel pulse width modulator faulty.
Light in probe red LED?
No
LED driving transistors *) blown, PAL D3 faulty
Yes
Input or intermediate amplifiers blown, *) pulse width modulator or optoisolators blown, digitally controlled amplifier circuitry faulty (D4, D5).

*) see Figure 5.12 for signal waveforms.

NOTE: When doing any work on the measuring board care has to be taken that the patient isolation is not violated.

NOTE: When reassembling the measuring board see Figure 9.1 for the proper placement of the shields.

6.4.7 CPU board troubleshooting

Due to the complexity of the LSI circuitry there are few faults in the CPU digital electronics that can be located without special equipment. The following checks may be performed:

a) The RAM, EPROM, CPU, and other socketed I.C.s are properly installed and the memory configuration jumpers are correct (see Figure 5.16).

b) The 11.059 MHz (rev. 05 and below) or 16 MHz (rev. 06 and up) clock signal at the CPU pins 18 and 19 (use a high impedance probe to check) is present.

c) PSEN (CPU pin 29) shows that instructions are being fetched. If this line is static, the processor is not running.

d) RESET (CPU pin 9) is normally low, but pulled up to +5 V for a moment after power up. If RESET is constantly high, check the +5 V supply line for spikes or low voltage.

The analog part is somewhat easier to troubleshoot. The input analog voltages are easily tracked to the MUX input. After the MUX, the voltages are multiplexed so that the resulting waveform is of 200 - 600 Hz frequency.

IR analog output is updated every 10 ms. All other analog output channels are updated every 40 ms. Thus the D/A conversion interval is 5 ms.

6.4.7.1 Instructions after replacing the software or CPU board

After replacing the software or CPU board:

- perform the gas calibration.
- re-establish previously used settings or inform the monitor user that all other settings are default values.

6.4.8 Video ASIC board troubleshooting

Due to the number of components in video ASIC board, we recommend changing the complete board in case of failure.

6.4.9 Power supply board troubleshooting

The following troubleshooting chart will help in pinpointing a malfunctioning component. The only part that requires good understanding of operating principles are the switching supplies. Consult the IC data sheet for more information on the LM 3524 switcher controller.

Table 6.3 Power supply board troubleshooting chart

SYMPTOM	POSSIBLE CAUSE/REMEDY
No voltages.	Secondary fuses F3 and F4 blown. NOTE: They usually get blown at the same time. Voltage reference (A2) blown, L3 blown.
Both switcher voltages missing.	Faulty switcher IC (A1 or A3), power FET; bipolar trans.
One switcher voltage missing.	NOTE: If the FET is shorted it usually shorts the Transzorb zener (V6, V23) and blows the secondary fuses.

6.4.10 Mother board/Keyboard troubleshooting

Fault finding on the mother board/Keyboard is reduced to:

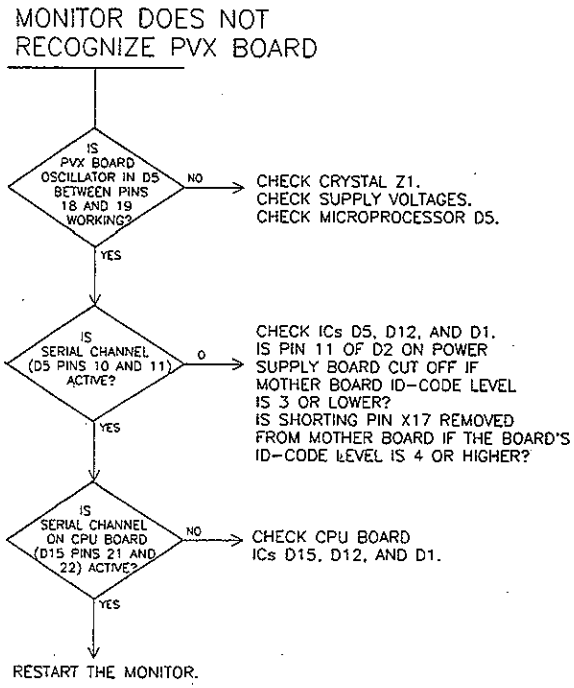
- visual inspection of board surface and connectors
- continuity and short circuit testing with an ohmmeter
- measuring of power supply voltages.

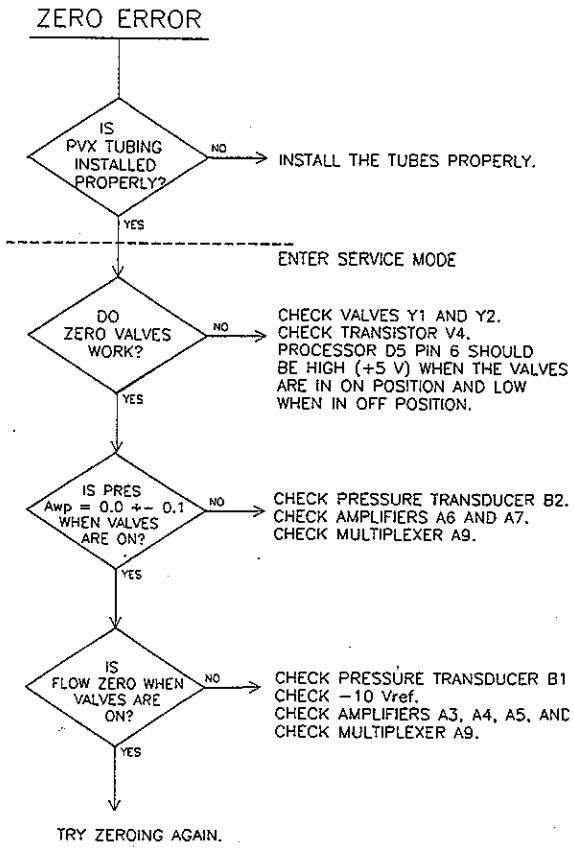
6.4.11 PVX board troubleshooting

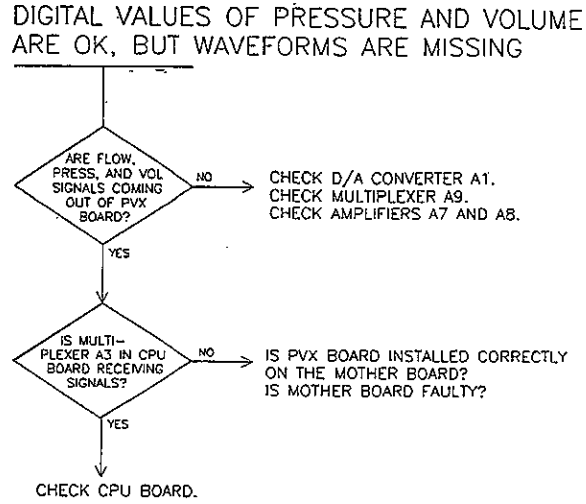
See the following flow charts to troubleshoot the PVX board.

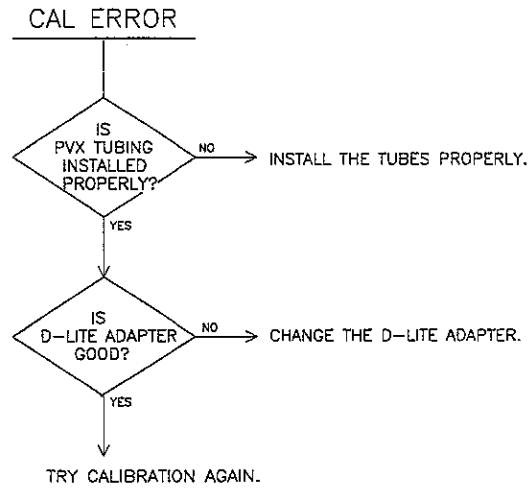
NOTE: Pressure transducers B1 and B2, and EEPROM D4 are replaced only at the factory.

NOTE: Never apply overpressure or negative pressure of more than 300 cmH2O to the flow and volume tubing.


MONITOR DOES NOT RECOGNIZE PVX BOARD
IS PVX BOARD OSCILLATOR IN D5 BETWEEN PINS 18 AND 19 WORKING?
NO
CHECK CRYSTAL Z1.
CHECK SUPPLY VOLTAGES.
CHECK MICROPROCESSOR D5.
YES
IS SERIAL CHANNEL (D5 PINS 10 AND 11) ACTIVE?
0
CHECK ICs D5, D12, AND D1.
IS PIN 11 OF D2 ON POWER SUPPLY BOARD CUT OFF IF MOTHER BOARD ID-CODE LEVEL IS 3 OR LOWER?
IS SHORTING PIN X17 REMOVED FROM MOTHER BOARD IF THE BOARD'S ID-CODE LEVEL IS 4 OR HIGHER?
YES
IS SERIAL CHANNEL ON CPU BOARD (D15 PINS 21 AND 22) ACTIVE?
NO
CHECK CPU BOARD ICs D15, D12, AND D1.
YES
RESTART THE MONITOR.


ZERO ERROR
IS PVX TUBING INSTALLED PROPERLY?
NO
INSTALL THE TUBES PROPERLY.
YES
ENTER SERVICE MODE
DO ZERO VALVES WORK?
NO
CHECK VALVES Y1 AND Y2.
CHECK TRANSISTOR V4.
PROCESSOR D5 PIN 6 SHOULD BE HIGH (+5 V) WHEN THE VALVES ARE IN ON POSITION AND LOW WHEN IN OFF POSITION.
YES
IS PRES Awp = 0.0 +- 0.1 WHEN VALVES ARE ON?
NO
CHECK PRESSURE TRANSDUCER B2.
CHECK AMPLIFIERS A6 AND A7.
CHECK MULTIPLEXER A9.
YES
IS FLOW ZERO WHEN VALVES ARE ON?
NO
CHECK PRESSURE TRANSDUCER B1
CHECK −10 Vref.
CHECK AMPLIFIERS A3, A4, A5, AND
CHECK MULTIPLEXER A9.
YES
TRY ZEROING AGAIN.


DIGITAL VALUES OF PRESSURE AND VOLUME ARE OK, BUT WAVEFORMS ARE MISSING
ARE FLOW, PRESS, AND VOL SIGNALS COMING OUT OF PVX BOARD?
NO
CHECK D/A CONVERTER A1.
CHECK MULTIPLEXER A9.
CHECK AMPLIFIERS A7 AND A8.
YES
IS MULTI-PLEXER A3 IN CPU BOARD RECEIVING SIGNALS?
NO
IS PVX BOARD INSTALLED CORRECTLY ON THE MOTHER BOARD?
IS MOTHER BOARD FAULTY?
YES
CHECK CPU BOARD.



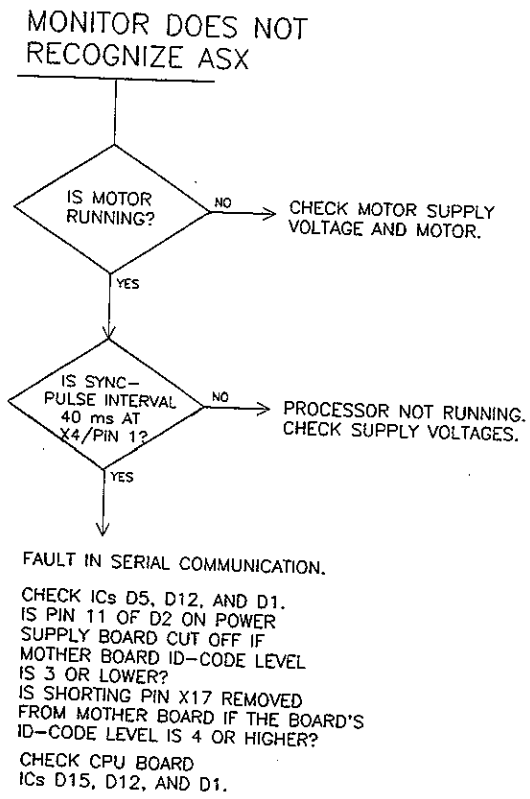
6.4.12 ASX Troubleshooting

NOTE: Please read also "Error messages" in Service mode section and the troubleshooting pages in Operator's Manual. The part of this chart is duplicated from them.

CAUTION: The agent identification benches ASX-100/200 can only be repaired and calibrated at DATEX-ENGSTROM. If the motor assembly, preamplifier board, EEPROM, temperature measuring components or the reflectance sensor A1 have failed the unit must be repaired and recalibrated at the factory. Temperature compensations and temperature zero can only be calibrated at the factory.

Table 6.4 ASX troubleshooting chart

TROUBLE	POSSIBLE CAUSE/REMEDY
MIXED AGENT-message when calibration gas is fed	Repeat calibration. (Note: ASX softwares of level -1.0 and -1.1 are not capable to identify calibration gas R23 and the "MIXED AGENT" message will appear instead of "CAL GAS IDENTIFIED" message).
No response from ASX	Communication between ASX unit and CPU board is lost. ASX bench disconnected or faulty. Check that the motor is running.
ASX TEMP OUT OF RANGE-message	ASX bench is beyond the temperature range (5 to 60 degrees centigrade). It is probably too cold. Warm it up and start the monitor again.
ASX EEPROM OUT OF LIMITS-message	EEPROM contents are false. If the message appears repeatedly, change the ASX unit.
ASX EEPROM WRITE ERROR-message	Write to EEPROM not succeeded. If the message appears repeatedly, change the ASX unit.
ASX ROM CHECKSUM ERROR-message	EPROM contents are false. Change the component.
ASX AUX RAM ERROR-message	Auxiliary RAM failed. Change the component.


MONITOR DOES NOT RECOGNIZE ASX
IS MOTOR RUNNING?
NO
CHECK MOTOR SUPPLY VOLTAGE AND MOTOR.
YES
IS SYNC-PULSE INTERVAL 40 ms AT X4/PIN 1?
NO
PROCESSOR NOT RUNNING. CHECK SUPPLY VOLTAGES.
YES
FAULT IN SERIAL COMMUNICATION.
CHECK ICs D5, D12, AND D1.
IS PIN 11 OF D2 ON POWER SUPPLY BOARD CUT OFF IF MOTHER BOARD ID-CODE LEVEL IS 3 OR LOWER?
IS SHORTING PIN X17 REMOVED FROM MOTHER BOARD IF THE BOARD'S ID-CODE LEVEL IS 4 OR HIGHER?
CHECK CPU BOARD ICs D15, D12, AND D1.

6.4.13 Cleaning the measuring chamber of ACX measuring unit

In case the N_2O "zero calibration constant" in Gas Service (ULT) or N_2O "calib zero" in ACX Service (AM) indicates contamination of the measuring chamber (value 61000 or more), or if the software will stuck to the "calibrating gas sensor" state due to contamination, it is possible to attempt the measuring chamber cleaning. However, we recommend exchanging the measuring unit rather than cleaning.

The measuring chamber should first try to be cleaned by rinsing it with *distilled water only*. If *rinsing* alone is not sufficient the cleaning can be tried with DATEX-ENGSTROM Cleaning Fluid (85969).

> **NOTE:** Do not use other cleaning agents such as blood gas electrode cleaners. They may damage the unit. Use only DATEX-ENGSTROM Cleaning Fluid (85969).

Cleaning procedure

Tools needed:

- 10 ml syringe
- water glass
- 2 pcs 30 cm silicon tubes with inner diameter of 3 mm
- screwdriver

a) Detach the measuring unit from the monitor or gas module

b) Attach the silicon tubes to the tube connectors on the unit

c) Attach the 10ml syringe to one of the tubes

d) Place the tip of the other tube into the water glass

e) Pour some distilled water into the glass

f) Suck the water into the tubing with the syringe

g) Leave for 15 minutes

h) Move the syringe piston in and out 10 times

i) Detach the tubes from the unit and empty the water from the measuring chamber

j) Attach one silicon tube to the unit and connect the other end of the tube to the gas outlet of the monitor or gas module

k) Switch the monitor on and let the sample out flow dry out the unit at least for 15 minutes

l) Attach the unit back to the monitor or gas module and switch the monitor on

m) Let the monitor run at least 30 minutes before checking the calib zero in the service mode

n) If the zero value is still more than 61000, repeat the procedure with the Cleaning Fluid

NOTE: After cleaning with the Cleaning Fluid the measuring chamber must be well rinsed with distilled water.

NOTE: The monitor will stay in "Calibrating gas sensor" state until the measuring chamber is completely dry.

7 ADJUSTMENTS

7.1 Adjustments after component replacements

COMPONENT REPLACED	ADJUSTMENTS
SAMPLING SYSTEM	After any work on the sampling system check the flow rates and adjust them if necessary (see Section 7.2).
CO_2/N_2O/AA MEASUREMENT	
IC's, diodes, transistors or passive components	Gas calibration.
ACX measuring unit	Gas calibration.
ASX unit	Always time offset and lambda calibration and checks of all limits in ASX service menu.

NOTE: Pressure transducers B1, B2, and EEPROM D4 on the PVX board are replaced only at the factory.

NOTE: The agent identification bench ASX should be repaired and calibrated at DATEX-ENGSTROM. Motor assembly, preamplifier board, EEPROM, temperature measuring components or the reflectance sensor A1 are replaced only at the factory.

NOTE: The ACX photometer and its components are repaired/calibrated at the factory. Attempts to repair/calibrate the unit elsewhere will adversely affect operation of the unit.

7.2 Gas sampling system adjustment

Flow rates should be measured and possibly adjusted under the following conditions:

- After any part within the sampling system has been replaced
- Gas response is slow

NOTE: Before adjusting the flows replace the D-FEND^{TM} water trap if necessary.

NOTE: Let the monitor warm up for 30 minutes before measuring flow rates.

For the flow rate measurements a flowmeter with a low flow resistance and capability to measure low flow rates is required. When making measurements a normal length of sampling line has to be connected to the monitor as it has a considerable effect on the flow.

The flow rates are adjusted by changing the flow resistance cassettes (constriction cassettes) in the sampling system. See Table 5.2 for the alternative cassettes.

The adjustments and the respective constrictions to be adjusted are shown in Figure 7.1.

FLOW RATE

If any flow rates are not correct, first replace the D-FEND^{TM} water trap. Then recheck the incorrect flows before adjusting the flow rates.

Total flow rate is measured by rotameter at the sampling line. The rate should be between 180 and 220 ml/min. The flow rate is adjusted by changing the constriction cassette which is located behind the pump (No. 22).

Rate of the side flow is checked by blocking the side flow after the water trap and measuring the flow rate as above. The rate should decrease by 10 to 26 ml/min.

Measurement flow and reference flow of the oxygen measuring unit are checked as follows:

(a) Connect rotameter behind the constriction cassette (No. 24) ahead of the oxygen measuring unit REF inlet. The rotameter should show between 26 and 35 ml/min. The flow rate is adjusted by changing the cassette.

(b) Connect rotameter between the oxygen measuring unit IN inlet and the tube which is connected to it. The flow rate should be between 18 and 25 ml/min **larger** than the REF flow. This is adjusted by changing the constriction cassette (No. 21) which is located between the IN and OUT inlets.

(c) Flow rate of CO_2 absorber is measured by connecting rotameter to the unoccupied connector of the constriction cassette located on the absorber. Make sure that the monitor is in normal situation (APNEA text on the screen). The flow rate should be zero. When the gas zeroing takes place, the rate should be more than 180 ml/min. The gas zeroing can be triggered by the CAL key and by performing gas calibration with the 1 key. The flow rate is adjusted by changing the cassette (No. 20).

CAUTION: When changing cassettes make sure that the tubes are reconnected properly.

Flow to be adjusted	**Constr. No. (see Figure 7.1)**	**Nominal value (tolerance) ml/min**
total flow	22	200 (180 to 220)
side flow	23	10 to 26
O_2 measurement in	21	45 to 60
O_2 reference in	24	26 to 35
CO_2 absorber flow	20	more than 180 when zeroing

NOTE: Changing any of the cassettes will have some effect on the other flow rates. After any adjustments check the other flow rates as well.

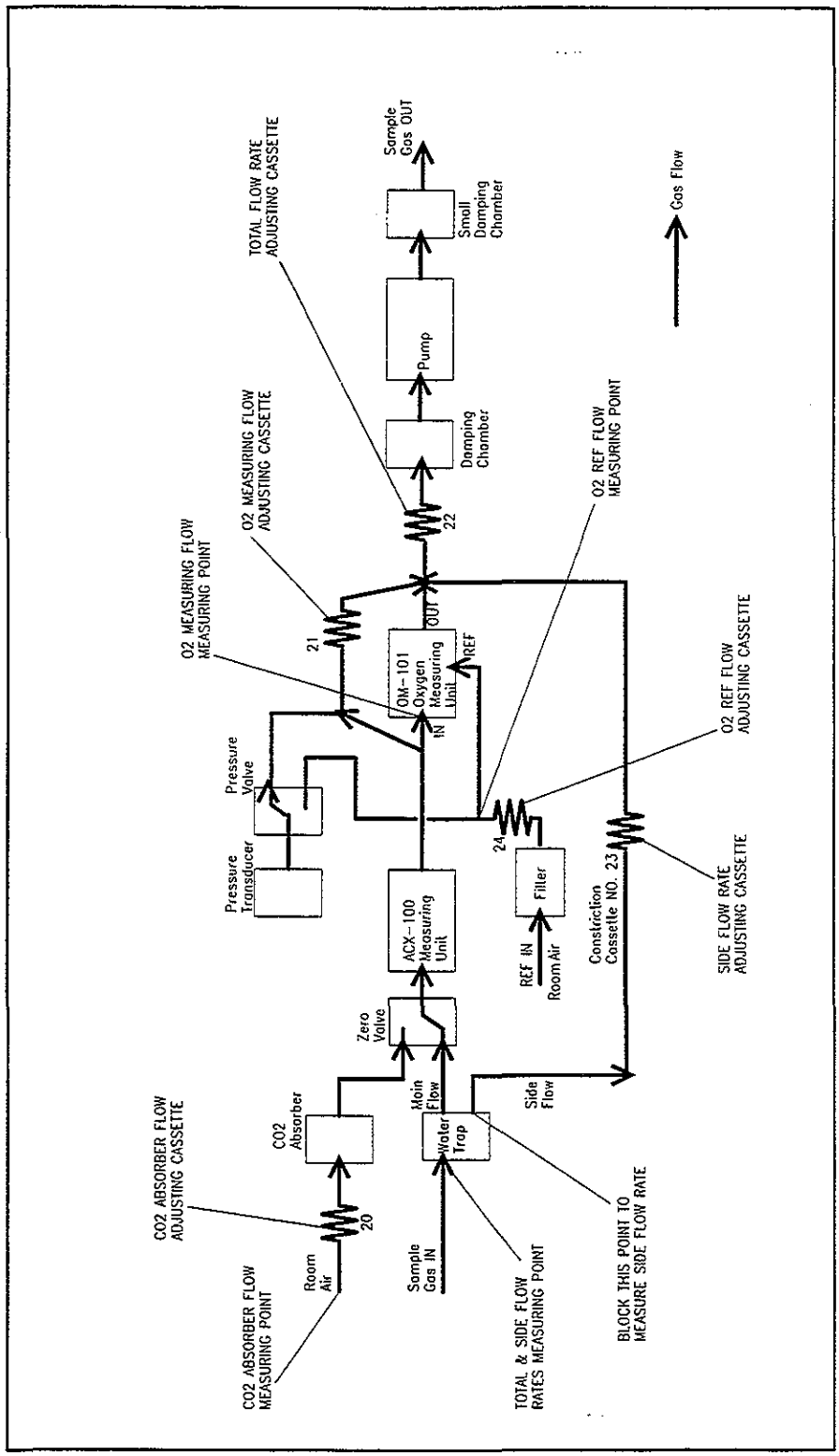


Figure 7.1 Gas sampling system adjustment chart

O_2 measurement flow pressure measurement

Gradual decrease of main flow rate due to the water trap filter clogging can be checked by measuring pressure difference between the O_2 measurement flow and the O_2 reference flow. Remember that the sampling line should be attached to the water trap during test.

The pressure difference is automatically checked after every gas zeroing.

The pressure difference can be manually calculated as follows:

Enter GAS SERVICE in the Service Mode

a) Set pump on, both valves closed (this is the normal operation situation). Check the PRE value. It is the pressure of the O_2 sensor measurement flow.

b) Press the 2 key to open the pressure valve. Now the PRE value shows the pressure of the reference flow.

c) Subtract the value gained in step 2 from the value gained in step 1 and you will have the pressure difference between the O_2 measurement flow and the O_2 reference flow.

The pressure difference should be between 5 to 10 mmHg (factory adjusted).

If the pressure difference is too large, decrease the measurement flow rate by changing the cassette no. 21.

When the pressure difference becomes negative, that is, the pressure in the reference flow gets higher than that of the measurement flow, and reaches -5 mmHg, then during normal monitoring the message "REPLACE TRAP" appears and the audible alarm sounds to indicate that the water trap should be replaced.

7.3 Oxygen measurement adjustments

The only field service procedures for the O_2 measuring unit are the offset(zero), gain, and frequency adjustments. In case of any other trouble, the measuring unit should be replaced and the faulty one sent to DATEX-ENGSTROM for repair.

7.3.1 Offset (zero) adjustment

Because the oxygen measuring unit is a differential sensor, which actually measures the difference between the O_2 concentrations in the sample and reference gases, its output must be adjusted to equal zero when atmospheric air is present at both inputs.

a) Use the service menu or connect a digital voltmeter to the output of the O_2 measuring unit at pin 5 of connector X13 on the mother board.

b) Let the monitor draw in room air and adjust the voltage to zero with the O_2 measuring unit trim resistor designated 'ZERO' (see Figure 7.2) in the O_2 module pc board. The potentiometers are located at the same side of the measuring unit as the tubing connectors.

c) Perform software calibration (refer to Operator's Manual).

7.3.2 Gain adjustment

a) Adjust the O_2 measuring unit offset as described in the previous section.

b) Sample 100 % oxygen and adjust the measuring unit output to between 7.7 V and 8.3 V with the trim resistor designated 'Gain' (see Figure 7.2). If the voltage will not reach to 7.7 V it can be left between 5.0 V to 7.7 V.

c) Check and if necessary readjust the offset and gain until the readings remain stable.

c) Perform software calibration (refer to Operator's Manual).

7.3.3 Temperature compensation adjustment

Factory calibrated.

7.3.4 Frequency adjustment

The switching frequency of the electromagnet of the O_2 measuring unit has been selected to be 110 Hz or 165 Hz to avoid interference from harmonics of both 50 Hz and 60 Hz mains frequency.

Fine adjustment is seldom necessary. However if you wish to reduce the effects of mechanical resonance peaks of the cabinet which appears as high noise level of the O_2 measuring unit analog output (above 20 mV peak to peak) it is worth of trying the fine frequency adjustment. One turn of trimmer "F" will change the frequency by 1.5 Hz. Try to find minimum noise but do not deviate more than ±5 Hz.

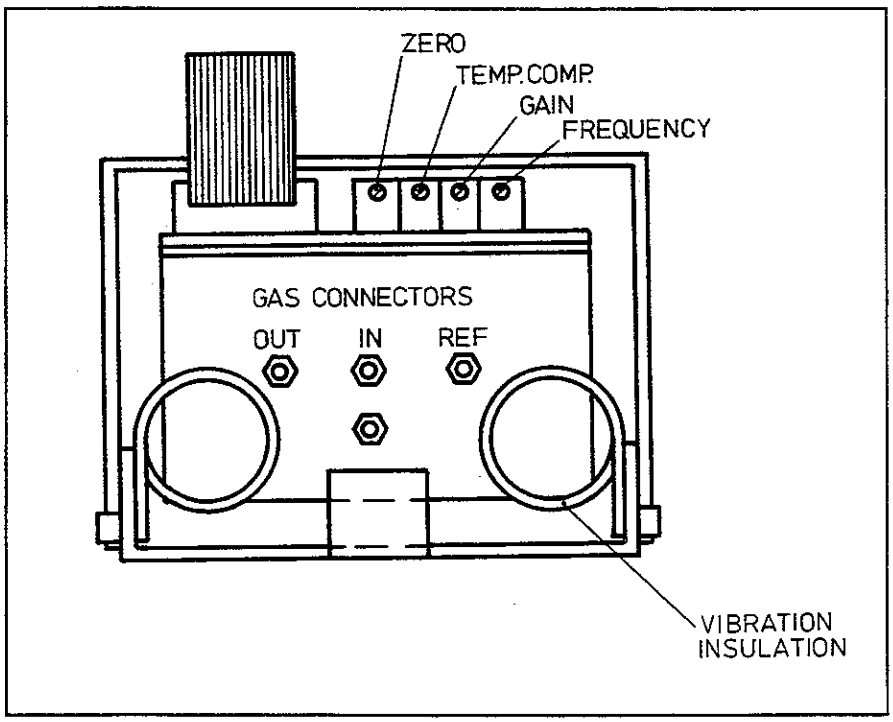


Figure 7.2 O_2 measuring unit adjustments

7.4 CPU board adjustment

> **NOTE:** This adjustment is valid only for CPU board (p/n 878822; rev. 00 to 05). High speed CPU board (p/n 883450; rev. 06 and up) does not need any adjustment.

There is one adjustable capacitor on the CPU board for real time clock oscillator frequency. It is factory adjusted, but may need to be readjusted if some components are replaced.

Real time clock oscillator frequency

The real time clock oscillator frequency is set by connecting a counter to pin 15 of D16 and adjusting C49 to read 256.00 Hz corresponding to a cycle time of 3906.25 us.

7.5 Video Display Unit (Philips) Adjustments

The following adjustments can be done in the Philips CRT display board (rev. 07 adaptation 27 only):

Basic brightness adjustment	Trimmer potentiometer P4
Horizontal width	Trimming inductance L1
Vertical height	Trimmer potentiometer P2
Horizontal positioning	Trimmer potentiometer P1
Horizontal linearity	Trimming magnet L2
Focus	Trimmer potentiometer P3

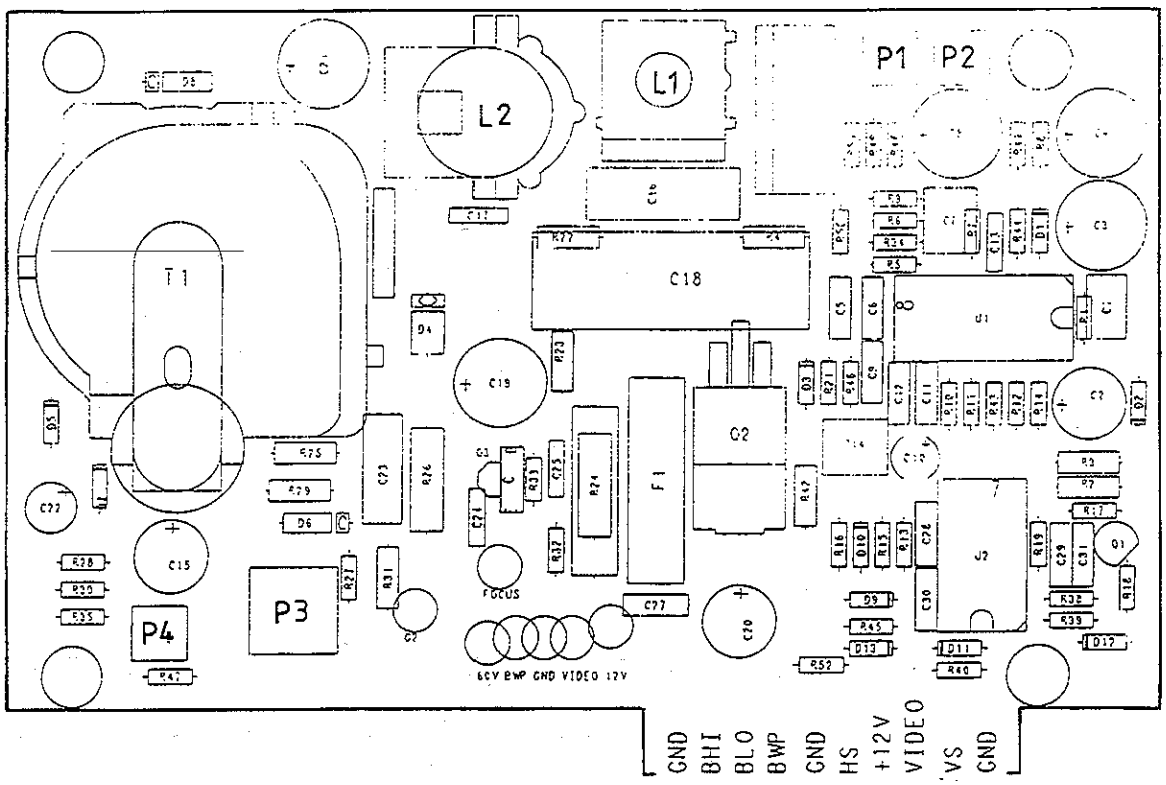


Figure 7.4 Video display unit (Philips) schematic diagram

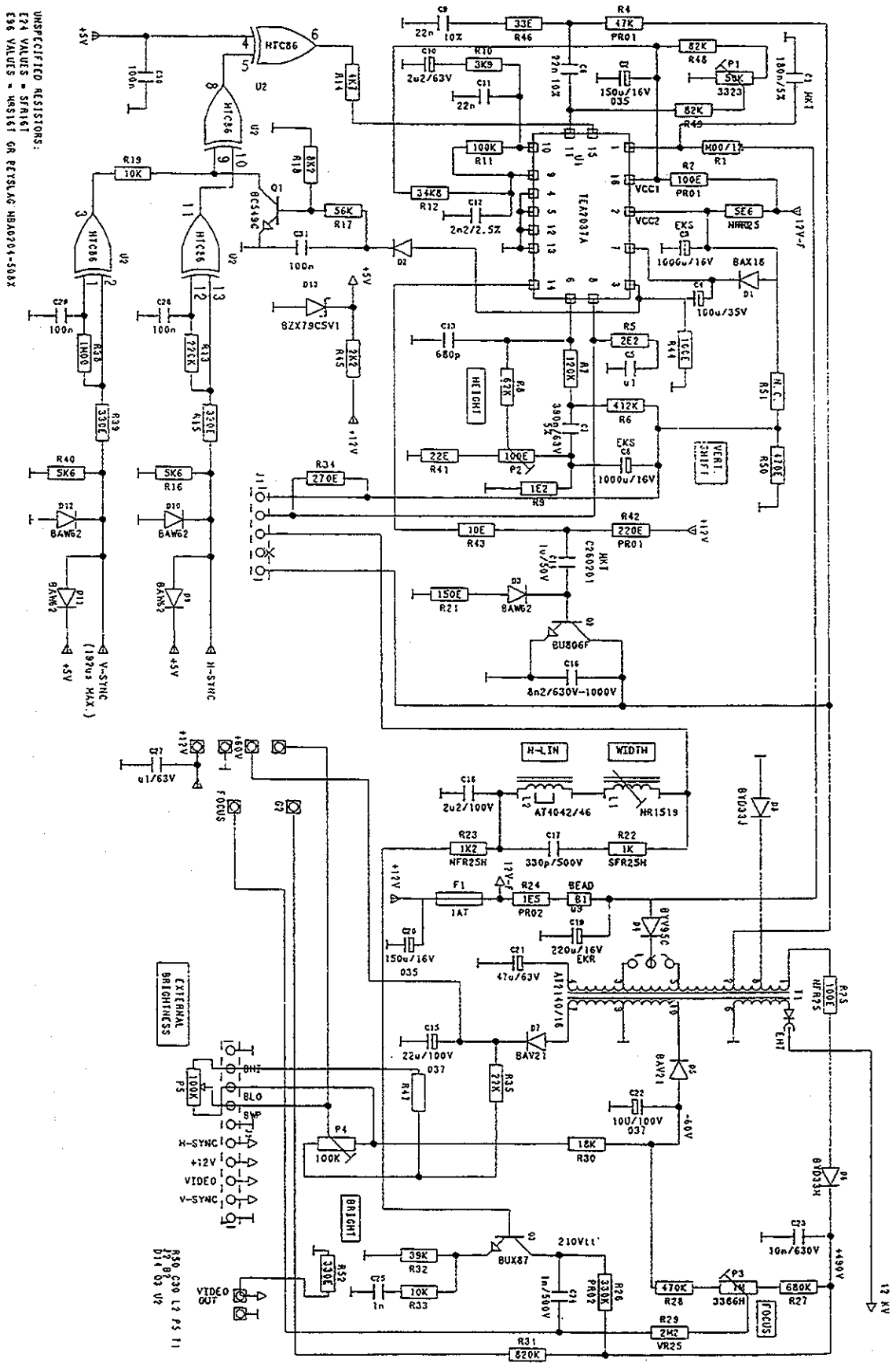
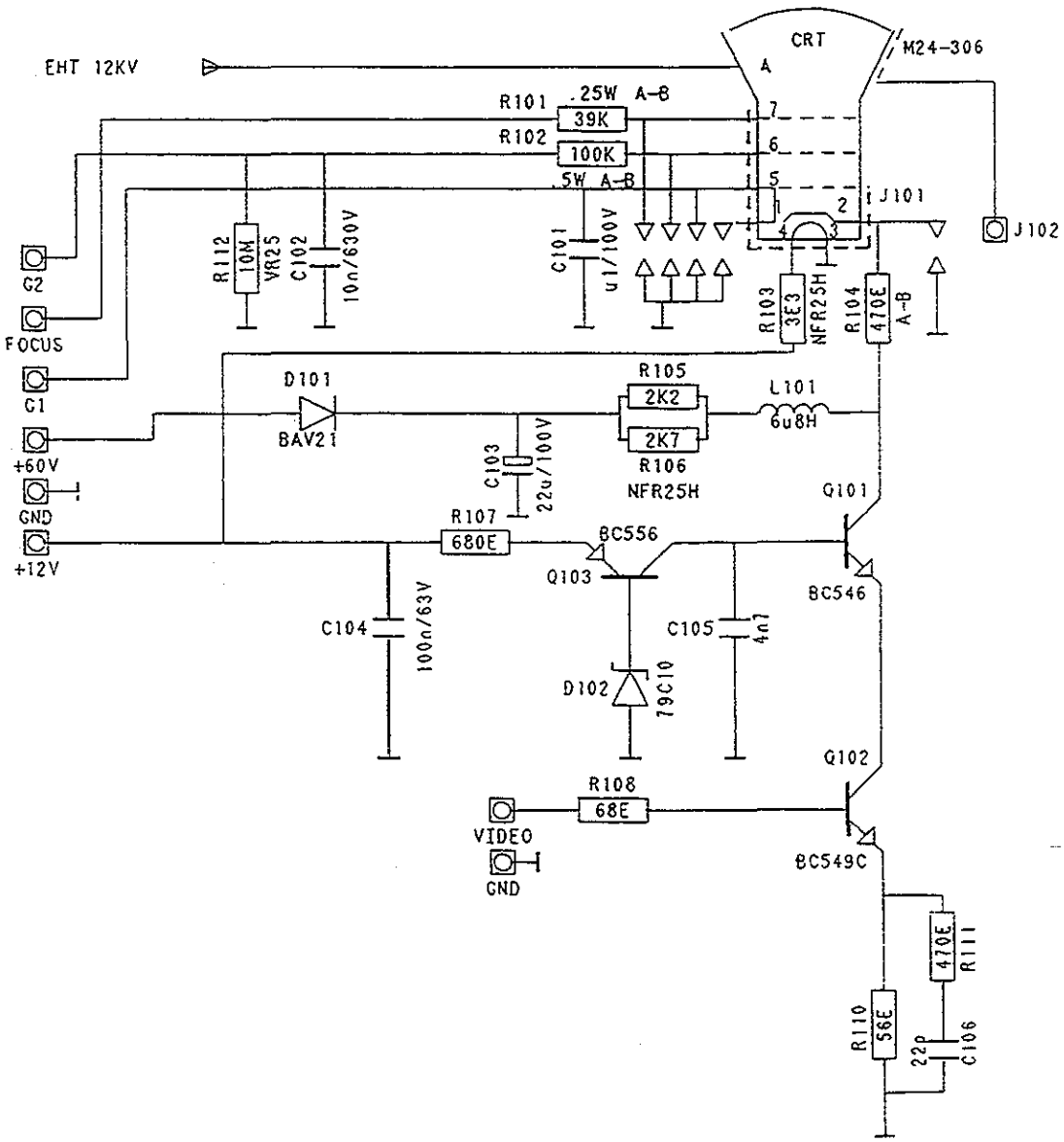


Figure 7.3 Video display unit (Philips) schematic diagram



R111 C106 J101 L103
Q102 D101

8 FUNCTIONAL FIELD CHECK PROCEDURE

8.1 Preoperative check list

Perform the following tests daily to assure proper operation of the monitor.

> **WARNING:** If the monitor fails to respond as described, stop using the monitor, troubleshoot, and correct the situation.

1. AIRWAY GASES

a) Confirm that the water trap container is empty and tightly attached, and the water trap is properly attached to the monitor.

b) Connect the gas sampling line to the connector on the water trap.

> **NOTE:** Occlusion pressure limit is set during start-up. Attach sampling line before turning monitor on.

c) Turn the power on. The monitor performs a start-up and self test procedure. Wait until message "CALIBRATING GAS SENSOR" disappears.

d) Confirm that the inspiratory O_2 reading is about 21 %, and no other gas is detected.

e) Breath five times into the sampling line to verify that a capnogram and end tidal value are displayed and they are in expected range. If not, calibrate the monitor, see the Operator's Manual. Calibrate the monitor every 6 months even if there is no sign of errors.

f) Stop breathing into the sampling line. After 20 seconds the monitor should give the first audible and visible alarm indicators.

2. PULSE OXIMETER

a) Connect the pulse oximeter probe to the monitor. The message 'NO PROBE' is replaced by 'PROBE OFF'.

b) Check that red light is emitted from the emitter, and the probe surface is undamaged.

c) Attach the probe to your finger. Wait for the pulse search to be done and readings to stabilize.

d) Verify that the PR and SpO_2 values are in the expected range, and that the plethysmographic pulse wave is regular.

3. PRESSURE AND VOLUME

a) Verify that the D-LITE™ and the tubes are connected correctly.

4. AGENT IDENTIFICATION

a) Feed calibration gas (p/n 755582) into the sampling line in normal monitoring mode. If the message "CAL GAS IDENTIFIED" comes up, the identification is functioning properly. (Note: ASX softwares of level -1.0 and -1.1 are not capable to identify calibration gas R23 and the "MIXED AGENT" message will appear instead of "CAL GAS IDENTIFIED" message.)

8.2 Checks after component replacements

The following test should be performed after any service to ensure proper operation of the monitor.

1. VISUAL INSPECTION

a) Constriction cassettes, water trap, oxygen measuring unit, valves, and pump are connected with tubes in correct order.

b) Tubes are not clogged (no shape bends nor jams).

c) Tubes are not touching the pump or oxygen measuring unit.

d) Tubes are properly pushed in to the connectors.

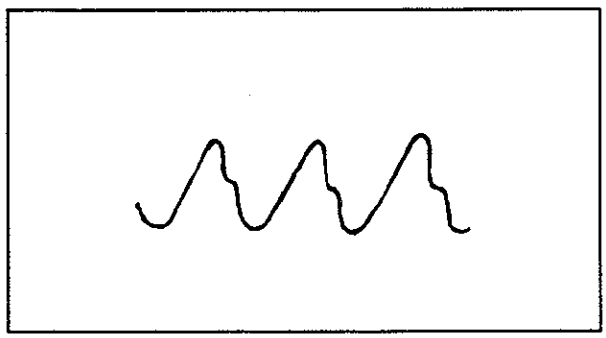
Connect power cord and sampling line. Turn the power on and wait until the initialization is over. Set the real time correct in SETUP MONITOR menu.

Check that no error messages are shown.

2. PULSE OXIMETER (ULT-S model)

Be sure that the text "NO PROBE" is on the screen. Connect a finger probe. The text "PROBE OFF" appears shortly on the screen.

Put your finger into the probe. The text "PROBE OFF" should disappear. Make sure that the monitor shows an appropriate pulse rate (PR 60 to 80), oxygen saturation value (SpO_2 94 to 99), and draws a waveform shown here.



Connect printer with measurement cable to Serial & Analog I/O connector on the rear panel. Make sure that the voltage changes in synchronization with pulse waveform.

3. LOUDSPEAKER

Check the operation of the loudspeaker with an alarm.

4. AUTOMATIC GAS ZEROING

Check that 5 minutes after power up the automatic zeroing takes place. This is indicated by the 'ZEROING, PLEASE WAIT' message. After zeroing the gas displays should read:

CO_2	0.0 % or 00 mmHg
O_2	21 %
N_2O	0 %

5. GAS ZERO AND CALIBRATION

Let the monitor draw in room air for 2 minutes before starting the calibration.

The calibration is performed as follows:

Press the CAL key and choose GAS CALIBR.

Wait until the monitor finishes zeroing.

Feed calibration gas till the monitor recognizes it.

Correct gas value with the MENU key.

Exit calibration by pressing NORMAL SCREEN key.

When all the gas are calibrated, recheck the calibrated values once again. Perform the calibration again if necessary.

6. OCCLUSION TEST

First be sure that the monitor initialization is over. Stage occlusion by blocking the sampling line. Check that the Occlusion alarm comes on. Check both audible and visual alarms.

7. GAS SAMPLING SYSTEM CHECK

Perform Gas Sampling System Leak Test, Water Separation Test, and Response Time Test (See Section 6.4.3 Gas Sampling System Troubleshooting).

8. AIR LEAK TEST

Detach the water trap. The text "AIR LEAK" appears on the screen.

Attach the trap again. The text "AIR LEAK" should be replaced by "APNEA".

9. SAMPLING SYSTEM PRESSURE

Choose Service menu and then GAS SERVICE. The pressure value on the screen (PRE) will be about 700 mmHg (depending on atmospheric pressure). Block the sample gas out connector and the pressure should rise about 60 mmHg.

10. FLOW ZERO AND CALIBRATION

NOTE: Due to hardware and software improvements, this flow zero and calibration is **not necessary**. However, if there is a reason for verification, perform flow zero and calibration with **Spirometry tester** (p/n 884202; Instruction for use is accompanied). The procedures below are still valid but not recommended.

a) Connect the power cord and sampling line and turn the monitor on. Wait for 5 minutes for the monitor to warm up.

b) Press the SETUP SCREEN key and choose P_{aw} in the top field and V in the middle field of the screen. Press the NORMAL SCREEN key to return to waveform display.

c) Connect D-lite™ sensor to the monitor. Connect Luer connector of thin tube to D-fend™ water trap. Attach calibration pump to the D-lite™ connector.

NOTE: The calibration is recommended to be performed with an average size of endotracheal tube really used with the monitor. The accuracy of the calibration is increased by 3 to 4 % if performed with exactly the same accessories (endotracheal tube, filters, elbows...) connected to the D-lite™ as are during normal use.

d) Work on the calibration pump slowly. When the piston is pulled out, the waveform (V) should be above the dotted line. When pushed in, below the dotted line. If contrary, the tubes are connected in wrong way.

e) Block the other end of the D-lite™ with a finger and work on the pump. When the piston is pushed in, the waveform (P_{aw}) should be above the dotted line. When pulled out, below the dotted line.

f) Detach the D-lite™ from the pump and block the both ends of the D-lite™ with fingers. The OCCLUSION alarm should appear after about 10 seconds. If the alarm does not appear, there may be a leak in the pressure and volume tubing.

g) Attach the calibration pump to the D-lite™ again. Press the CAL key to go into calibration mode. Choose FLOW CALIBR. Press zero and wait for 5 seconds. Then work on the pump slowly and send full volume into the monitor about 7 times until arrow figures appear on the screen. Correct the reading to 1000 ml with the arrow keys. Press the NORMAL SCREEN key to return to waveform display.

h) Press the SPIROMETRY key and work on the pump as in the previous step. Check that the values in TV insp and TV exp are 1000 ml. If the values deviate more than 25 ml, repeat the steps g and h.

11. DATA RETENTION

Breathe into the sampling line for at least 15 seconds. Check by pressing the TREND key that the CO_2 measurement results are enough to draw trend waveform.

Disconnect power cord for 20 seconds. Then connect it back and turn the monitor on. When the initialization is over, make trend displayed on the screen. The trend which had been measured before the power cut-off, should be displayed. If it's not displayed, the monitor should be serviced by qualified service personnel.

12. VERIFICATION AND FINAL CHECKS

Check the leakage current of the unit. Check the condition of all cables and connectors.

SERIAL INTERFACE

Connect serial printer to serial & analog I/O connector on the rear panel of the monitor. Turn the power on and check that the printer prints data alright.

FINAL VISUAL INSPECTION

a) Real time and date is correct. The date can be checked in Service menu.

b) There are no dirt stains in the monitor.

c) Top cover, side panels, and bottom plate are properly attached with screws.

Preventive Maintenance Check List

Client _____

Service _____ Monitor type _____ S/N _____

Service engineer _____ Date _____

All models:

(3*) PM Kit parts replaced	(18) Pump test
(6) Gas values within limits	(19) Ambient - PRE
(9) Software versions	(20) OM ref - OM in
(10) Error list	(21) Fall times
(12) N2O zero constant	(22) O2 sensor output
(13) Ambient pressure	(24) Steam test
(14) CO2 absorber	(25) Occlusion test
(15) Zero valve	(26) Air leak test
(16) Leak test	(27) Gas calibration
(17) Flow rates	

Monitors with Agent Identification:

(29) Cal gas identified	(31) Peak normal - Peak mirror
(30) Peak normal	(31) ASX calibrated

Monitors with Patient Spirometry:

(32) Spirometry connectors	(37) Flow waveform
(33-36) Leak test	(38) Check with Spirometry tester

Monitors with SpO2 measurement:

(40) No probe	(42) Pleth waveform
(41) Probe off	(42) SpO2 reading
(42) Pulse search	

All models:

(45) Electrical safety check	(47) Gas information correct
(45) Leakage current test	(48) Apnea alarm

Notes:

* Numbers in parenthesis refer to the items of Preventive Maintenance Instructions
Fill: OK=Check/Test OK, N.A.=Not applicable, Fail=Test failed, Any other notes

Preventive Maintenance Instructions

Tools needed:

Screwdrivers
Tools for blocking internal tubes
A glass of water
Flowmeter
Multimeter
Calibration gas (order code 755582)

Parts needed:

Preventive Maintenance Kit containing: D-fend, D-fend body connector O-rings, Sampling line, Nafion tube(s), OM ref filter and Dust filter

D-lite
(Pedi-lite)
SpO_2 finger probe
Spirometry tube
Silicon tubes
Constriction cassettes

The following preventive maintenance checks are recommended to be performed after any service repair or at least once a year in order to ensure proper functioning of the monitor. Put the checking notes on the preventive maintenance check list.

The parts included in the Preventive Maintenance Kit are recommended to be replaced once a year.

Closer instructions for most of the tests can be found in this Service Manual.

For all Ultima models

1. Remove the top cover, side plates and the small door on the bottom.

   Note: Electrostatic discharge through PC boards may damage components. Wear a static control wrist strap when handling PC boards.

2. Check internal parts:

   - screws are properly tightened
   - cables are properly connected
   - all IC's that are on sockets are properly attached
   - tubes are not pinched and there are no sharp bends on them

- tubes are properly connected
- there are no loose objects inside the module

Note: Make sure that none of the tubes is in contact with the sampling pump or O_2 sensor.

3. Replace the parts included in the Preventive Maintenance Kit

   Note: Use only Datex-Engstrom sampling lines in order to ensure proper functioning.

4. Connect the mains cable and switch the monitor on.

5. Check that the fan is running.

6. Wait until the message "Calibrating gas sensor" disappears from screen, then feed calibration gas (755582) to the sampling line and check that the values are within the limits;

   CO_2 5.0% +/- 0.4%
   ENF 3.0% +/- 0.4%
   O_2 55% +/- 4%
   N2O 33% +/- 4%

   If the values are out of the limits, perform gas calibration before proceeding to the next item.

7. Push the Mark/Reset key as long as the Startup menu appears.

8. Enter the Service Menu (3)

9. Write down the information regarding software versions.

10. Enter the Error list (3) for checking possible error messages.
    Push "Normal Screen" to return to the Service Menu.

11. Enter the Gas Service (1)

12. Check that the "Calibration constants" zero value for N_2O is less than 61000. If the value exceeds the limit, it indicates bad contamination in the ACX measuring chamber and the whole ACX measuring unit is then need to be exchanged.

    Note: If the ACX measuring unit is exchanged due to contamination, also the tube from measuring unit to zero valve, the zero valve, and the tube between zero valve and D-fend should be replaced.

Note: Cleaning of the measuring chamber can be tried as "first aid" but we recommend exchanging the measuring unit rather than cleaning.

13. Check that the shown "Ambient Press" -value corresponds to the current ambient pressure (± 20 mmHg).

14. Check the CO_2 absorber.
Place the tip of the sampling line away from you and let the monitor draw in room air. Check the CO_2 real time value. If the value is less than 0.04, replace the CO_2 absorber. (0.00 indicates total absorber malfunction).

15. Check the zero valve.
Activate (open) the Zero valve (3) and feed calibration gas (or some other gas that is available) to the sampling line. If the gas value(s) on screen change, replace the zero valve.

16. Perform the sampling system leak test.

17. Check the flow rates, adjust if necessary.

Note: If any of the constriction cassettes was exchanged, the leak test should be performed again.

18. Perform the pump test.
Block the tip of the sampling line by your finger until the PRE value becomes stable. If the difference between Ambient press and PRE is less than 110 replace the sampling pump and repeat items 16 - 18.

19. Check that the difference between Ambient press and PRE is within 50 - 75.

20. Open the Press valve (2) and check that the PRE value drops by 5 or more.
If the value drops less than 5, check the D-fend and readjust the flows if necessary.

21. Perform the Fall time measurement (4) in the Gas Service. Check that the measured fall times are within the ranges that are given in the Service Manual.

22. Feed calibration gas, order code 755582, and measure the O_2 sensor output voltage on the mother board connector X13 pin 5. The output voltage should rise at least up to 2.8 V (3.5V nominal).
Adjust the O_2 sensor output, if necessary.

23. Enter the monitoring mode by pushing the "Normal screen" button twice and then button 4 "Monitoring".
Skip to item 25 if the Nafion tube was replaced in item 3.

24. Perform the "Steam test". If the test is not passed, replace the Nafion tube.

    Note: The Nafion tube is recommended to be replaced once a year.

25. Block the tip of the sampling line by your finger and check that the message "Occlusion" appears onto the screen.

26. Detach the D-fend and check that the message "Air leak" appears onto the screen. Reattach the D-fend.

27. Perform the gas calibration.

    Note: The final gas calibration is not recommended to be performed before 30 minutes warm-up time.

For monitors that contain the Agent Identification

28. Enter the ASX Service menu.

29. Feed calibration gas and check that "CAL. GAS" appears on the right side of the "Ident." text.

    Note: ASX-100 with software 878364-1.1 or lower is not capable of identifying calibration gas R23 (order code 755582) and therefore the message "MIX" appears instead.

30. Keep feeding gas, check that the Peak norm. is close to 10.50 (+/- 0.2).

31. Check that the difference between Peak normal and Peak mirror is not more than 0.3.

    Note: If the values are out of the above range, perform the ASX calibration according to the Service manual instructions and check the values again.

For monitors that contain the Patient Spirometry

32. Check that the SSS -connectors at the front panel are clean and intact.

33. Connect a clean Spirometry tube to the module and a clean D-lite to the other end of the tube. Block the D-lite's sampling line port, for example with a Luer stopper.

34. Select the pressure waveform scale 20 cmH2O, and the flow waveform scale 15 l/min onto the monitor screen

35. Take the D-lite into your hand and occlude both ends tightly with your fingers (or with both hands). Pressing firmly with the fingers creates a pressure inside the D-lite. Check that pressure near 5 cmH2O is generated.

    Note: If the monitor has the male & female SSS -connectors (paediatric option), make sure that the date marking on the D-lite is 10/94 or newer.

36. If the system leaks heavily, no pressure will be generated. If there is a small leak in the connections, the monitor will measure a pressure difference which is then interpreted as flow and seen on the monitor screen. The pressure waveform decreases slowly and the flow waveform either goes above, or below the zero line, depending on which of the connectors leaks.
    In case of leakage, check all connections and try again.

37. Remove the blockage from the sampling line port and connect the sampling line. Breath through the wider side of the D-lite. Check that the flow waveform moves downwards when you breath in, and upwards when you breath out.
    If the flow waveform moves in opposite manner, check the order of the PVX tubes inside the monitor.

38. If possible, check the Side Stream Spirometry measurement also with the Spirometry Tester (order code 884202). Follow the instructions that are supplied with the tester.

For monitors that contain the SpO_2 measurement

39. Select the "Pleth" on some waveform field in "Setup screen" menu.

40. Check that the message "No probe" is shown when no SpO_2 sensor is connected to the monitor.

41. Connect a SpO_2 finger probe to the monitor. Check that the message
"Probe off" is shown when the probe is not connected to a finger.

42. Connect the SpO_2 probe to your finger. Check that the message "Pulse search" is shown and reading of 95-99 and the Pleth waveform will appear.

For all monitors:

43. Switch the monitor off, disconnect the mains cable and reassemble the monitor.

    Note: When reassembling the monitor, make sure that the tubes and cables are not pinched between the PC boards and covers.

44. Clean, or replace the dust filter. (If not replaced in item 3)

45. Perform electrical safety check and leakage current test.

46. Reconnect the mains cable and sampling line, switch the monitor on and wait until the message "Calibrating gas sensor" disappears from the screen.

47. Simulate at least 5 breaths by feeding calibration gas into the sampling line.
Check that the shown gas information is correct.

48. Check that "Apnea" message appears on screen and monitor gives audible alarm within 30 seconds after you have stopped feeding the gas.

49. Switch the monitor off, disconnect the mains cable and clean the monitor surface.

50. Fill in all necessary documents and the preventive maintenance sticker. Attach it to a suitable place on the monitor rear panel.

9 SPARE PARTS

9.1 Spare parts

For the locations of the main parts see Figures 9.1 and 9.2.

PCB

Item	Description	Order No.
21	SpO_2 measuring board (rev. 07 and up)	888210***
21	SpO_2 measuring board (rev. 05 and below)	875842*
21	SpO_2 measuring board (25; rev. 05 and below)	879348
21	SpO_2 measuring board (rev. 06)	881989
10	CPU board (11 MHz) (rev. 05 and below)	878822*
10	High Speed (16 MHz) CPU board (rev. 06 and up)	883450*
11	ACX-200 measuring board	880270*
11	ACX-200 measuring unit complete (incl. measuring board, bench, and software)	879838*
44	ASX-100 unit (incl. pc boards, bench, software)	881107
44	ASX-200 unit (incl. pc boards, bench, software)	882718
41	Power supply board unit	880882
9	Video control board (rev. 04 and below)	870646*
9	Video control board (rev. 05 and up)	883108*
9	Video control board (rev. 08 and up)	885480
22	Mother board	876003
	LED board (27)	877338
45	Transformer filter board	883899

NOTE: New main software and the High Speed CPU board are compatible with the old and new SpO_2 measuring board, and with ASX-100, ASX-200, ACX-100, and ACX-200 sensors.

NOTE: The SpO_2 measuring boards (881989 and 888210) operate only with the new main software (rev. 06 and up) and High Speed CPU board.

NOTE: ACX-200 measuring board measures Sevoflurane and Desflurane in addition to Halothane, Isoflurane, and Enflurane. The difference between the ACX-200 measuring board and ACX-100 measuring board is that the former contains several precision resistors. The ACX-200 measuring board can simply be used to replace the ACX-100 measuring board but not vice versa.

NOTE: The video control board (883108) can be installed into monitors of rev. 04 and below. The old video control board can not be installed into rev. 05 and up monitors.

***NOTE:** The parts have some effect on the EMC. They are compatible with the earlier revision monitors but the older revision parts may not be used in CE marked monitors.

NOTE: The video control board 885480 is compatible with all the different monitor revisions.

Power related parts

Item	Description	Order No.
37	Power cord (27,28,31)	86236*
37	Power cord (21,23)	54563*
15	Power cord receptacle block (rev. 07 and below, rev. 08 and below -27)	52124
15	Power cord receptacle block (rev. 08 and up, rev. 09 and up -27)	52128
24	Switch cable	52130
24	Switch cable (27) (rev. -08 and below)	52122
24	Switch cable (27) (Rev. 09 and up)	52131
5	Fuse holder (rev. 07 and below, rev. 08 and below -27)	51153
5	Fuse holder (rev 08 and up, rev. 09 and up -27)	51179
4	Mains fuse 2.5 A 250 V slow UL/CSA (27,28)	511181*
4	Mains fuse T 2.5 A 250 V (21,23,31)	51118*
30	Fuse 4 A, slow miniature (for 876831)	51060*
31	Fuse 3.15 A, slow (for 876831)	51119*
16	Mains transformer, 220-240 V (23,33,43)	878294*
16	Mains transformer, 100 V (31)	877916*
16	Mains transformer, 115 V (27,28,29)	878194*
45	Transformer case (27, rev. 05 and 06)	883138
45	Transformer case (27, rev. 07 and 08)	884782
45	Transformer case (rev. 08 and up, rev. 09 and up -27)	888597

Gas measurement related parts

33	Sampling pump	870678*
32	Internal sample tubing, complete (without i-parameter)	877028*
32	Internal sample tubing, complete (with i-parameter)	880263*
1	Constriction cassettes	see Table 5.2
	Special internal sample tube A	878098*
34	O_2 measuring unit, complete (rev. 06 and below)	872898*
34	O_2 measuring unit (rev. 07 and up)	888511***
6	Sample gas out connector	871981
38	Magnetic valve	58534*

Other internal parts

29	Video cable unit for Panasonic display	870644
29	Video cable unit (27, rev. 05 and 06) (For Panasonic)	883136
28	Video display unit, complete, Philips display	875244
28	Video display unit, complete (Panasonic display)	883170
26	Internal pulse oximeter cable	874689
19	Lithium battery on CPU board (rev. 05 and below)	17503*
44	SRAM with internal battery (High speed CPU board)	139422
36	Intermediary bottom plate	876284
13	ACX-100 Measuring unit (photometer)	874682*
13	ACX-200 Measuring unit (photometer)	879849*
	ASX lamp	878756
43	PVX unit	881444*
12	Protective plate for 870646	873860
12	Protective plate for 883108	883137
27	Video display frame	872761

Front panel related parts

Item	Description	Order No.
18	Keyboard unit (dark)	870645
18	Keyboard unit (white)	877513
	Keyboard sticker (1/S-27)	90250
	Keyboard sticker (V/SV-27)	90257
	V-sticker (V-27) (replaces 90252)	884420
	SV-sticker (SV-27) (replaces 90251)	884419
	Name Logo (27)	881311
25	SpO_2 panel unit (1) (replaces 877293)	876287
	SpO_2 hole plug	876991
25	SpO_2 panel unit (S)	876287
25	SpO_2 panel unit (V/SV, incl. tubes)	881848
25	SpO_2 panel unit (V/SV, incl. tubes; with pediatric measurement)	884747
25	SpO_2 panel unit (1/S-27, V/SV-27)	876832
	Front plate, metal	877480
	Front plate, metal (27, rev. 06 and lower)	876703
	Front plate, metal (27, rev. 07 and up)	884561
14	Front panel unit (1/S-21,23,28,31,33,43-dark)	878311
14	Front panel unit (1/S-21,23,28,31-white)	878314
14	Front panel unit (1/S-33-white)	878315
14	Front panel unit (1/S-43-white)	878316
14	Front panel unit (V/SV-21,23,28,31)	879185
14	Front panel unit (V/SV-33)	879187
14	Front panel unit (V/SV-43)	879186
	Front panel unit, complete	881283
14	Front panel unit (1/S-40)	891106
14	Front panel unit (V/SV-40)	891091
	Front panel unit, complete (27)	881284
23	Water trap, (D-FEND™) complete	875055**
	Spring for water trap	875598
	SpO_2 conn. masking sticker (1-27) (replaces 90254)	882439
	SpO_2 connector masking sticker (1-xx)	877079
	SpO_2 connector masking sticker (V-xx)	877078
	SpO_2 connector plug (1/V-xx)	876991
	SpO_2 connector sticker (S-27) (replaces 90253)	882438
	SpO_2 connector sticker (S-xx)	877082
	SpO_2 connector sticker (SV-xx)	877081

Rear panel related parts

2	Rear panel unit (21,23,31)	876535
2	Rear panel unit (27, rev. 06 and lower)	876565
2	Rear panel unit (27, rev. 07 to 08)	884785
2	Rear panel unit (28)	876949
2	Rear panel unit (40 rev. 08 and up)	890664
2	Rear panel unit (22, rev. 08 and up)	890543
2	Rear panel unit (28 rev. 08 and up, 27 rev 09 and up)	890544
2	Rear panel unit (29 rev. 08 and up)	890545
2	Rear panel unit (31 rev. 08 and up)	890548
2	Rear panel unit (33 rev 08 and up)	890546
2	Rear panel unit (43 rev. 09 and up)	890547
3	Loudspeaker unit	874619
17	Fan	870641
7	Dust filter	880832*

NOTE: When ordering front or rear panels, please specify the serial number and the full monitor code as found in the type shield on the rear panel.

Other external parts

Item	Description	Order No.
8	Top cover (dark)	871905
8	Top cover (white)	872894
8	Top cover (27)	877197
35	Enclosure bottom (dark)	871469
35	Enclosure bottom (white)	876601
42	Foot	65160
39	Side cover (dark)	871458
39	Side cover (white)	872893
40	Side cover screw	61655

Software

20	Main software EPROM	see page 9-5
	ACX software	881169
	PVX software	878728
	PVX software (with pediatric measurement)	885470

* = The part is recommended for stock.

** = The part is sold as an accessory.

Explanation of the codes and numbers used in the spare parts list

Monitor type designation

ULT-xx-yy-zz

xx: indicates the model of the monitor. It can be either 1, S, SV, V, i, Si, SVi, or Vi (see page 3-1).

yy: indicates the adaptation of the monitor. It is a 2-digit number.

zz: indicates the revision of the monitor.

History of ULTIMA revisions and main software codes

	English	French	German
First stage (autumn 1989)			
ULT-1-xx-00 (dark)	875345	877340	877412
ULT-1-27-00 (white)	875345	------	------
ULT-S-xx-00 (dark)	875345	877340	877412
ULT-S-27-00 (white)	875345	------	------
Second stage (summer 1990)			
ULT-1-xx-01 (white)	875345	877340	877412
ULT-1-27-00 (white)	878041	------	------
ULT-S-xx-01 (white)	875345	877340	877412
ULT-S-27-00 (white)	878041	------	------
Third stage (spring 1991)			
ULT-1-xx-02 (white)	879016	879245	879244
ULT-1-27-01 (white)	879016	------	------
ULT-S-xx-02 (white)	879016	879245	879244
ULT-S-27-01 (white)	879016	------	------
ULT-SV-xx-02 (white)	879016	879245	879244
ULT-V-xx-00 (white)	879016	879245	879244
Fourth stage (autumn 1991)			
ULT-1-xx-03 (white)	879016-2.1	879245-1.1	879244-1.0
ULT-1-27-02 (white)	879016-2.1	------	------
ULT-S-xx-03 (white)	879016-2.1	879245-1.1	879244-1.0
ULT-S-27-02 (white)	879016-2.1	------	------
ULT-S-25-00 (white)	879016-2.1	------	------
ULT-SV-xx-03 (white)	879016-2.1	879245-1.1	879244-1.0
ULT-SV-25-00 (white)	879016-2.1	------	------
ULT-V-xx-01 (white)	879016-2.1	879245-1.1	879244-1.0
ULT-i-xx-00 (white)	879016-2.1	879245-1.1	879244-1.0
ULT-Si-xx-00 (white)	879016-2.1	879245-1.1	879244-1.0
ULT-Vi-xx-00 (white)	879016-2.1	879245-1.1	879244-1.0
ULT-SVi-xx-0 (white)	879016-2.1	879245-1.1	879244-1.0
Fifth stage (winter 1992-3)			
ULT-x-xx-04 (white)	882312-1.0	882314-1.0	882313-1.0
Sixth stage (spring 1993)			
ULT-x-27-05 (white)	No software changes		
Seventh stage (winter 1993-4)			
ULT-x-xx-06	882916-1.0	882918-1.0	882917-1.0

Eighth stage (summer 1994)

	English	French	German
ULT-x-23/28/31-06	882916-3.0	--------	--------
ULT-x-27-07	882916-2.0	--------	--------
ULT-i/Si/Vi/SVi-29-06	--------	884203-2.0	--------
ULT-x-33-06	--------	--------	882917-3.0
ULT-x-43-07	--------	884234-2.0	--------

Ninth stage (autumn 1995)

	English	French	German
ULT-x-22/28/31-07	882916-3.1	------	------
ULT-x-27-08	882916-3.1	------	------
ULT-x-43-08	------	884203-3.1	------
ULT-x-33-07	------	------	882917-3.1
ULT-i/Si/SVi-29-07	------	884203-3.1	------

Tenth stage (summer 1996)

	English	French	German	Spanish
ULT-x-22/28/31-08	882916-4.0	------	------	------
ULT-x-27-09	882916-4.0	------	------	------
ULT-x-43-09	------	884203-4.0	------	------
ULT-x-33-08	------	------	882917-4.0	------
ULT-i/Si/SVi-29-08	------	884203-4.0	------	------
ULT-x-40-08	------	------	------	890662-4.0
ULT-1A-27-09	889859-4.0	------	------	------

9.2 Service accessories

Item description	Order No.
Extension board (lifts the board above the stack of boards to allow measurements)	872930
Quick cal calibration gas	755582
Reusable gas valve	755533
Flowmeter	874521
Spirometry test pump	880277
Spirometry tester	884202

Figure 9.1 Exploded picture of the monitor
(all except -27- model)

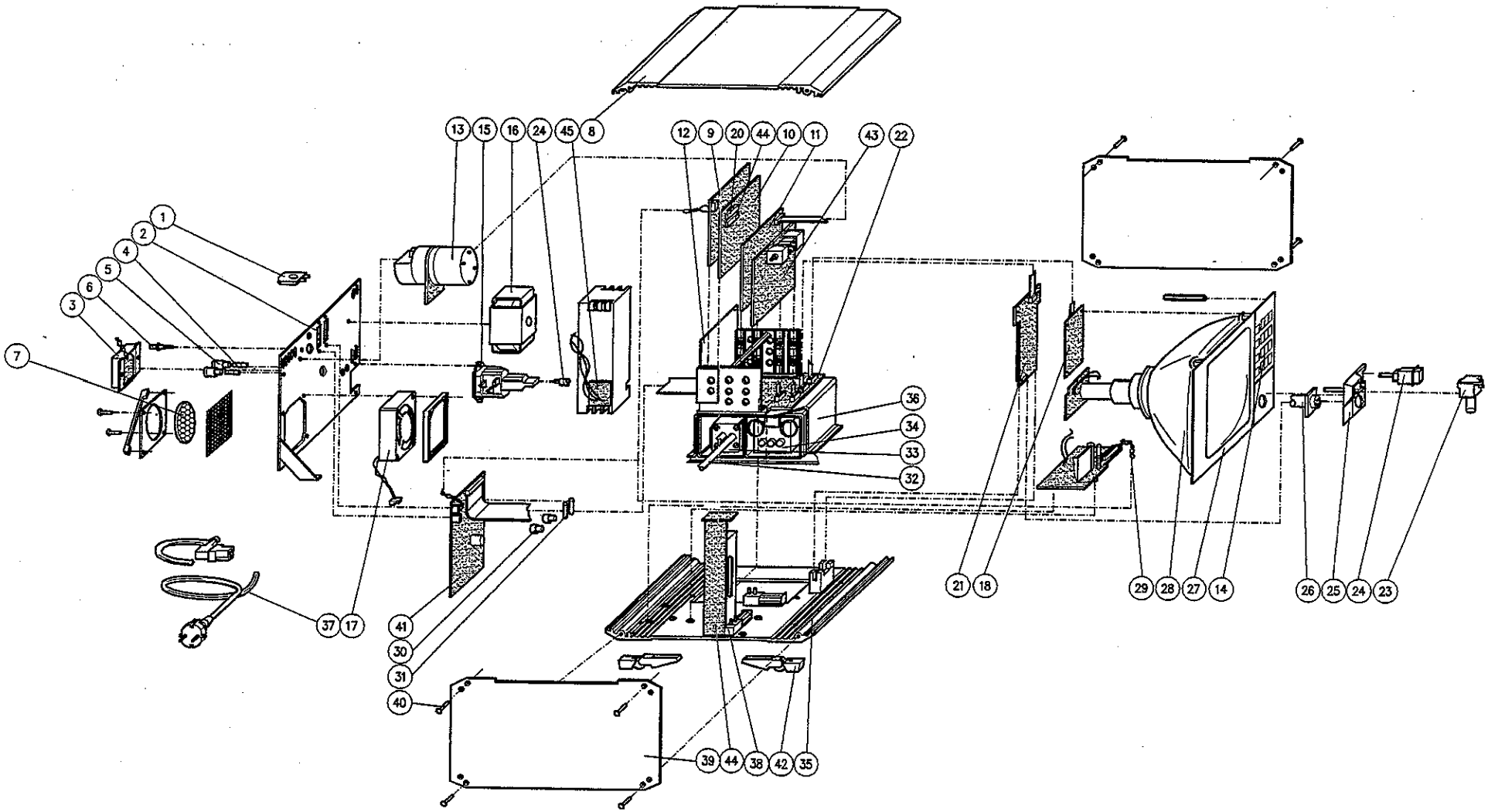


Figure 9.2 Exploded picture of the monitor
(-27- model revisions -08 and lower)

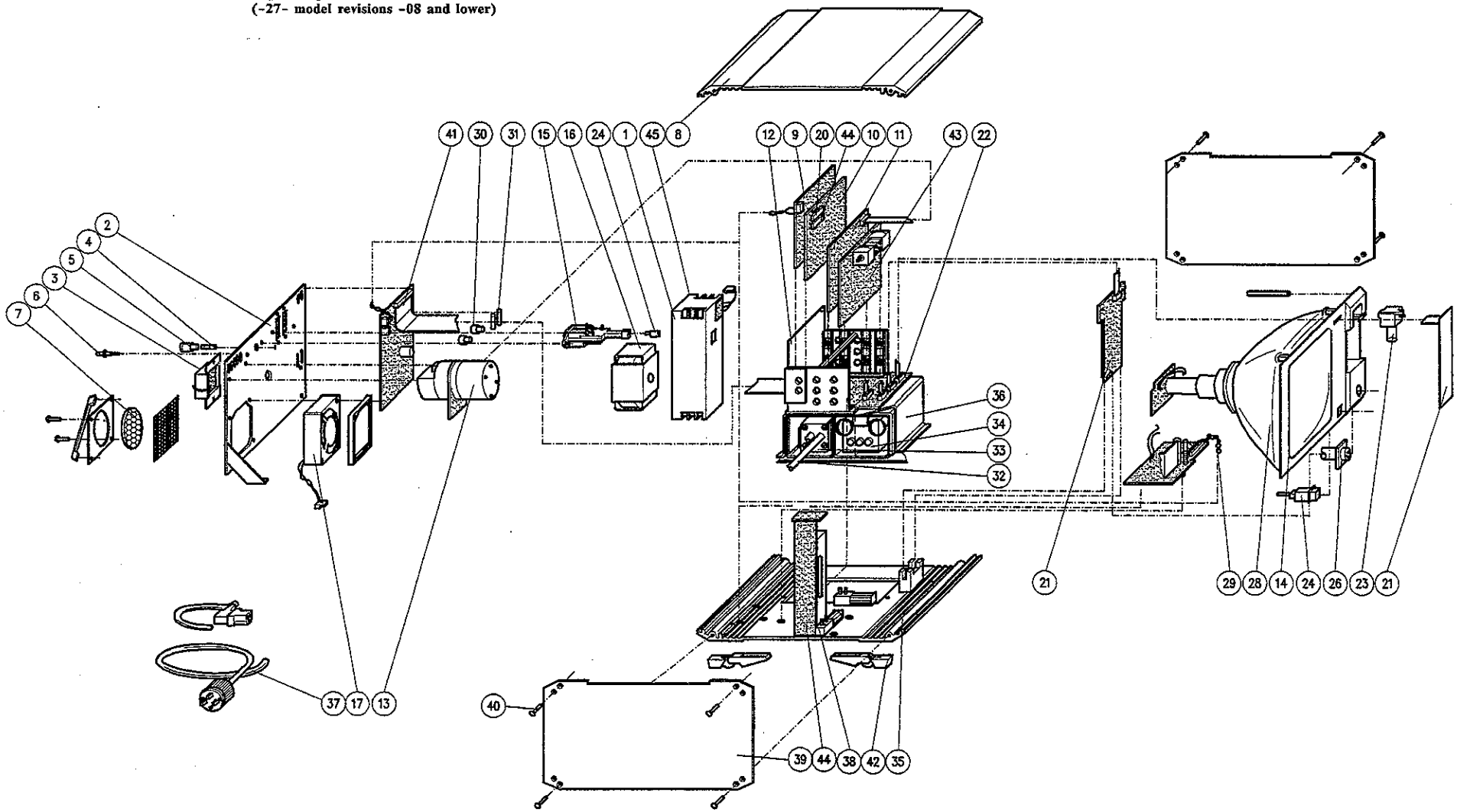


Figure 9.3 Exploded picture of the monitor
(-27- model revisions -09)

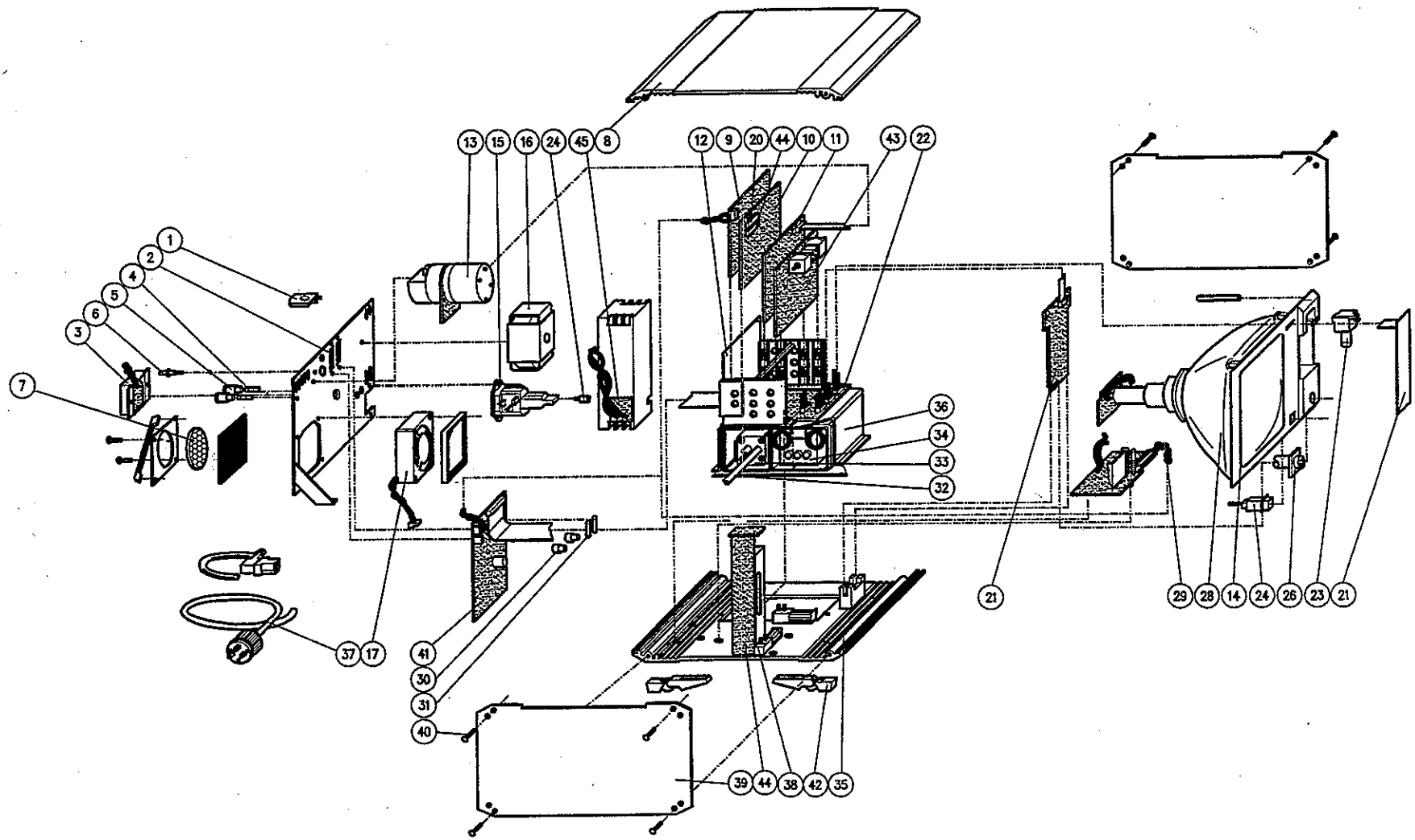
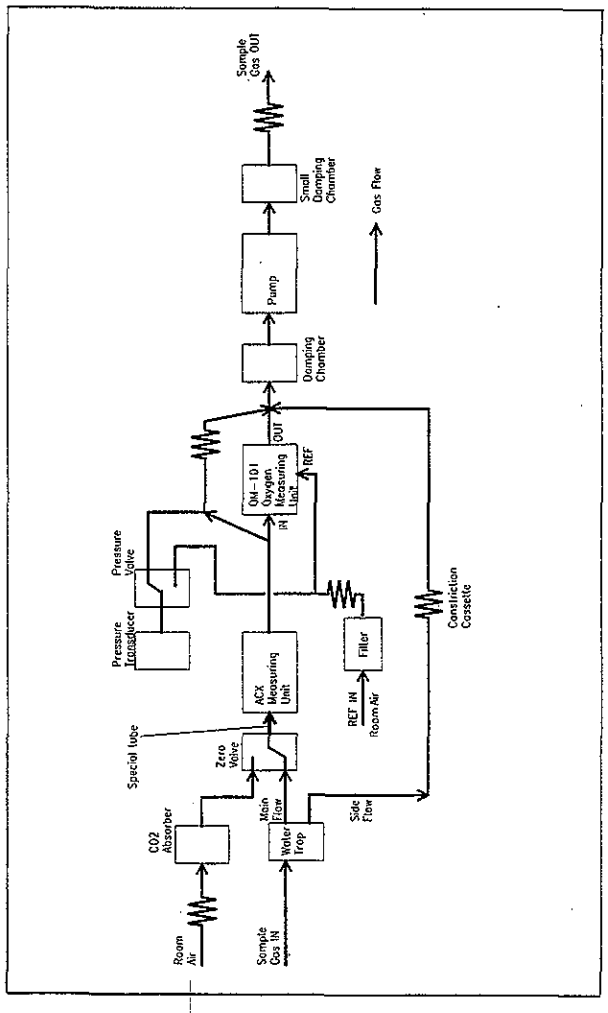
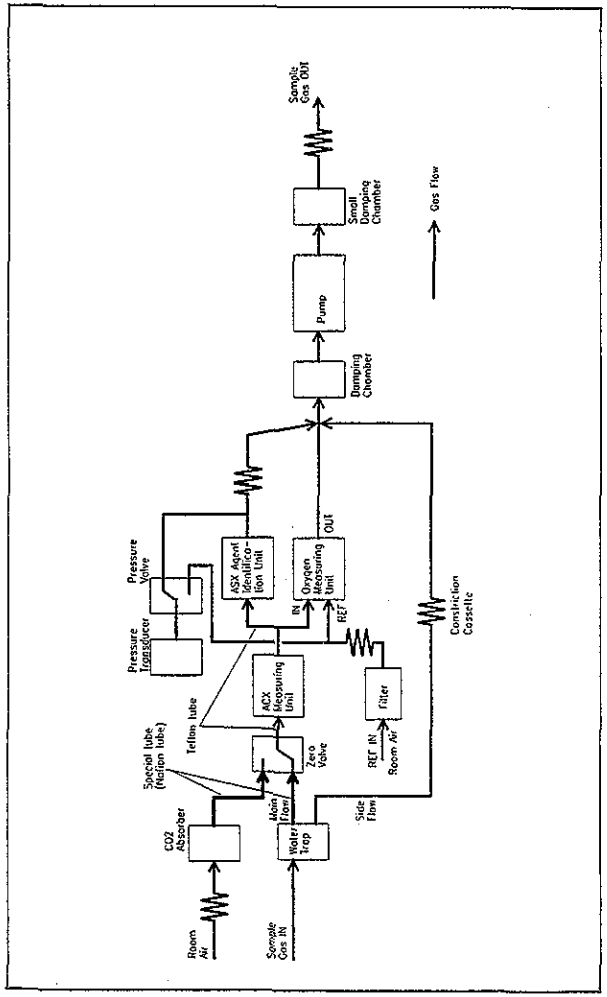


Figure 5.1 Gas sampling system schematic diagrams



Gas Sampling System without i-parameter



Gas Sampling System with i-parameter

Figure 5.2.1 Gas sampling system layout (without i-parameter)

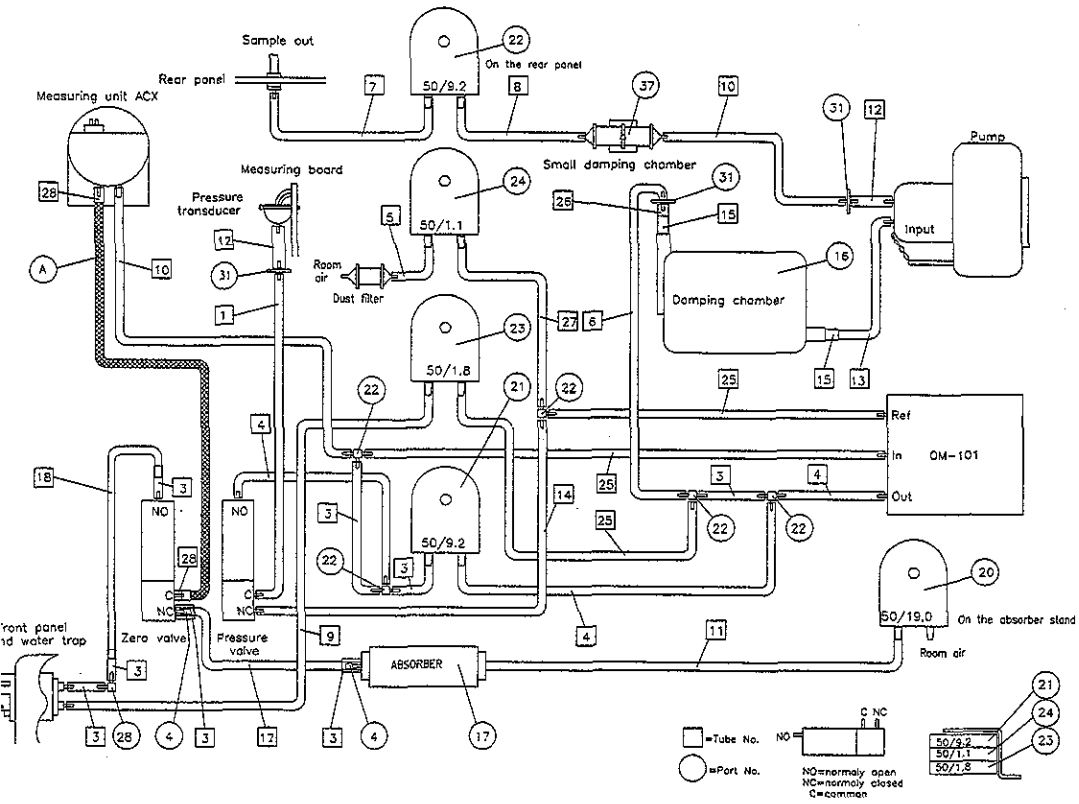


Table 5.1.1 Tube lengths (without i-parameter)

Tube No.	Part	Code	Pcs	Length/mm
A	Special sample tube	878098	1	500
1	1.7/1.05 mm Silicone	73373	1	280
3	1.7/1.05 mm Silicone	73373	8	20
4	1.7/1.05 mm Silicone	73373	3	50
5	1.7/1.05 mm Silicone	73373	1	60
6	1.7/1.05 mm Silicone	73373	1	180
7	1.7/1.05 mm Silicone	73373	1	85
8	1.7/1.05 mm Silicone	73373	1	110
9	1.7/1.05 mm Silicone	73373	1	300
10	1.7/1.05 mm Silicone	73373	2	400
11	1.7/1.05 mm Silicone	73373	1	150
12	3.18x6.35 mm Silicone	73375	2	20
13	3.18x6.35 mm Silicone	73375	1	180
14	1.7/1.05 mm Silicone	73373	1	70
15	4.8x9.5 mm Silicone	73376	2	25
17	1x2 mm PVC	73341	1	200
18	1.2x0.3 mm PTFE	73332	1	400
25	1.7/1.05 mm Silicone	73373	3	30
26	3.18/6.35 mm Silicone	73375	1	20
27	1.7/1.05 mm Silicone	73373	1	40
28	1.7/1.05 mm Silicone	73373	2	15

Part No.	Part	Code
20-24	Constriction cassette	Selected individually, see Table 5.2 for alternatives
16	Damping chamber	57150
17	Absorber	874643
22	T-piece	733821
28	L-piece	733811
31	Adapter piece	73388
36	Dust filter	86901
4	CNO metal tube	871925
37	Small damping chamber	878099

Note: Constriction cassettes are selected to adjust proper flow rates. See Table 5.2 for alternatives.

Figure 5.2.2 Gas sampling system layout (with i-parameter)

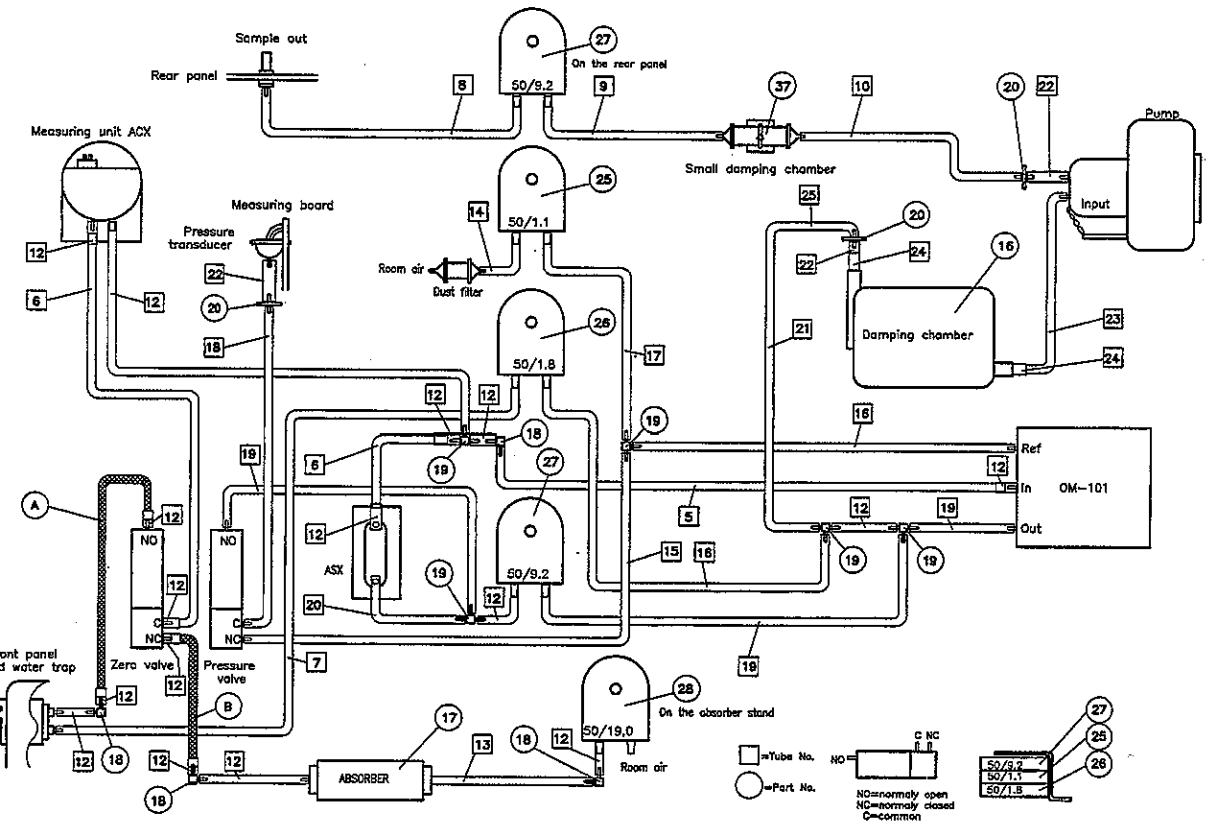


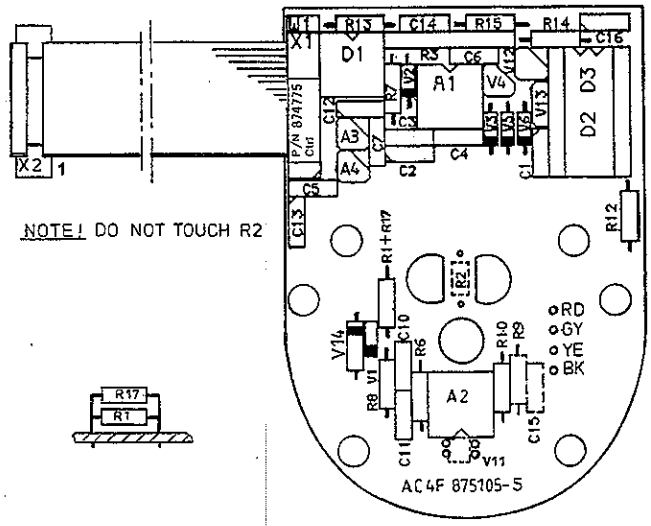
Table 5.1.2 Tube lengths (with i-parameter)

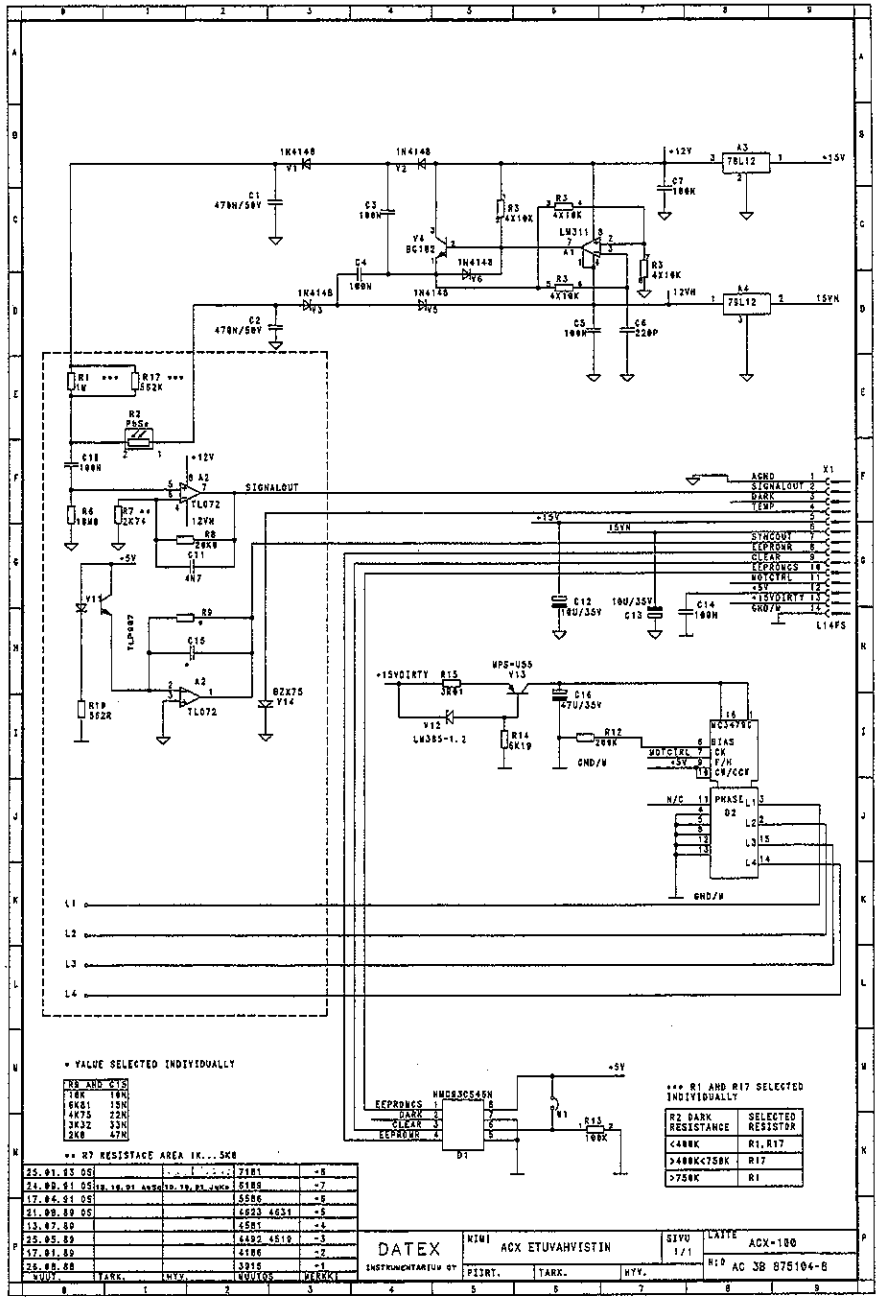
Tube No.	Part	Code	Pcs	Length/mm
A	Special sample tube	878098	1	500
B	Special sample tube	876432	1	300
5	1.2/0.3 mm PTFE	73332	2	400
6	1.2/0.3 mm PTFE	73332	2	320
7	1.7/1.05 mm Silicone	73373	1	300
8	1.7/1.05 mm Silicone	73373	1	85
9	1.7/1.05 mm Silicone	73373	1	110
10	1.7/1.05 mm Silicone	73373	1	400
12	1.7/1.05 mm Silicone	73373	17	20
13	1.7/1.05 mm Silicone	73373	1	140
14	1.7/1.05 mm Silicone	73373	1	60
15	1.7/1.05 mm Silicone	73373	1	70
16	1.7/1.05 mm Silicone	73373	2	30
17	1.7/1.05 mm Silicone	73373	1	40
18	1.7/1.05 mm Silicone	73373	1	280
19	1.7/1.05 mm Silicone	73373	3	50
20	1.7/1.05 mm Silicone	73373	1	220
21	1.7/1.05 mm Silicone	73373	1	180
22	3.18x6.35 mm Silicone	73375	3	20
23	3.18x6.35 mm Silicone	73375	1	180
24	4.8x9.5 mm Silicone	73376	2	25
25	10x2.5 mm Silicone	73377	1	50

Part No.	Part	Code
25-28	Constriction cassette	Selected individually, see Table 5.2 for alternatives
16	Damping chamber	57150
17	Absorber	874643
18	L-piece	733811
19	T-piece	733821
20	Adapter piece	73388
36	Dust filter	86901
37	Small damping chamber	878099

Note: Constriction cassettes are selected to adjust proper flow rates. See Table 5.2 for alternatives.

Figure 5.5 Preamplifier parts layout and schematic diagram (board modification level 8 and higher)





5.5 SpO_2 measuring board

Block diagram and schematic diagram part 1 Figure 5.10
Parts layout, timing diagram, and schematic diagram part 2 Figure 5.11
Signal waveforms and schematic diagram part 3 Figure 5.12
Schematic diagram part 4 Figure 5.13

The board is intended to perform the following tasks

- Control the LED light sources of the probe.
- Amplify the signal coming from the detector and separate the red and infrared signal components to respective channels.
- Multiplex in both channels the alternating component of the signal (plethysmographic pulse) with the signal proportional to the total intensity measured with the respective wavelength.
- Connect the multiplexer output channels (red channel and IR channel) to the CPU board isolatedly.

The isolated power supply is based on switcher controller circuit D1, which is used without any feedback from the secondary of T1. D1 performs as an oscillator of about 45 kHz. It also limits the current through T1 if overloading occurs.

The isolated supply voltages of +12 V and -12 V are regulated by zener diodes V18 and V19. +5 V supply is generated by a regulator A6.

The timing circuit is produced by a PAL (Programmable Array Logic) D3. The input signal of D3 (SYNC.) is taken from the switching power supply and its form is a 45 kHz square wave. All timing signals are synchronized at the switching frequency. The timing circuit controls the LED driving circuitry (signals LED_R and LED_{IR}), the RC time constants in amplifier chain (MEASURE) and sampling ($SAMPLE_R$, $SAMPLE_{IR}$).

The LEDs in the probe are driven with constant current pulses of a magnitude of 250 to 300 mA. The pulse duration and duty cycle can be seen in timing diagram in Figure 5.11. A positive voltage pulse at 1/X1 corresponds to the red LED current and a negative one to the IR-LED, respectively.

The signal coming from the detector is a current. The first amplifier stage is a current-to-voltage converter. A signal current passes through the resistors between pins 9 and 8 of A3 and produces a negative voltage pulse at 8/A3. Notice that the part of the feedback resistance is located in the probe connector.

Another resistor in the connector is connected to 6/X1 in order to form a bias current sink for the detector. At 5/X1 there is a constant bias voltage of about -4 V.

At 7/A3 the detected voltage pulses are inverted to positive value.

The digitally controlled amplifier is based on DAC D5 (Digital to Analog Converter). The signal is fed to the reference input of D5. The 8-bit digital control word is transferred over the patient isolation barrier in serial mode (PA2) and is converted into parallel mode by a shift register D4. The signal level at 14/A3 is adjusted to 3 to 8 V by the CPU.

The amplified signal pulses are separated to red and infrared channels by sample-and-hold circuitry (S/H). Voltages V_R and V_{IR} are proportional to the total intensity of the light detected at the respective wavelength. V_{Rac} and V_{IRac} are the amplified alternating components (plethysmographic pulses).

The signals are multiplexed into two channels by a 2 x 4 MUX A5. Also +5 V and GND are connected to MUX input. The value of the resistor R_C in the probe connector can be read through the red channel, if needed.

The two output channels of MUX A5 are transferred across the patient isolation by two identical pulse width modulator/optoisolator/demodulator-chains. The frequency of the pulse width modulator is about 20 kHz. The demodulated signal is inverted in comparison with the MUX output signal.

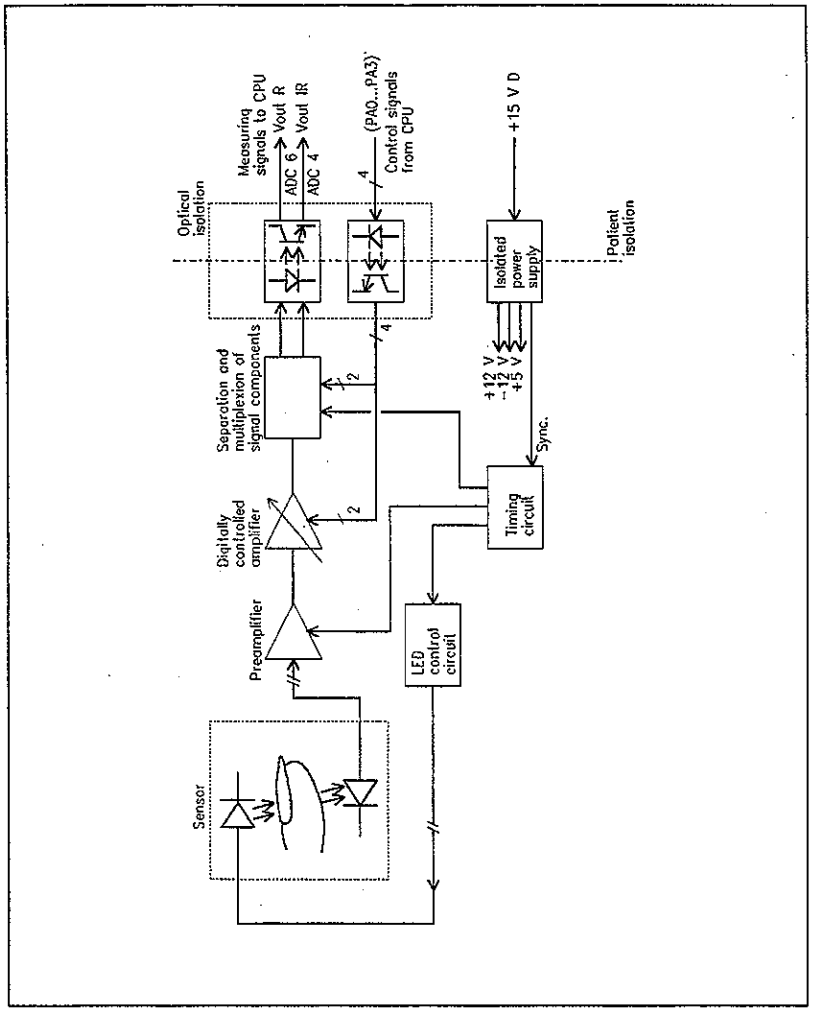


Figure 5.10 SpO_2 Measuring board block diagram and schematic diagram part 1 (board modification level 8 and higher)

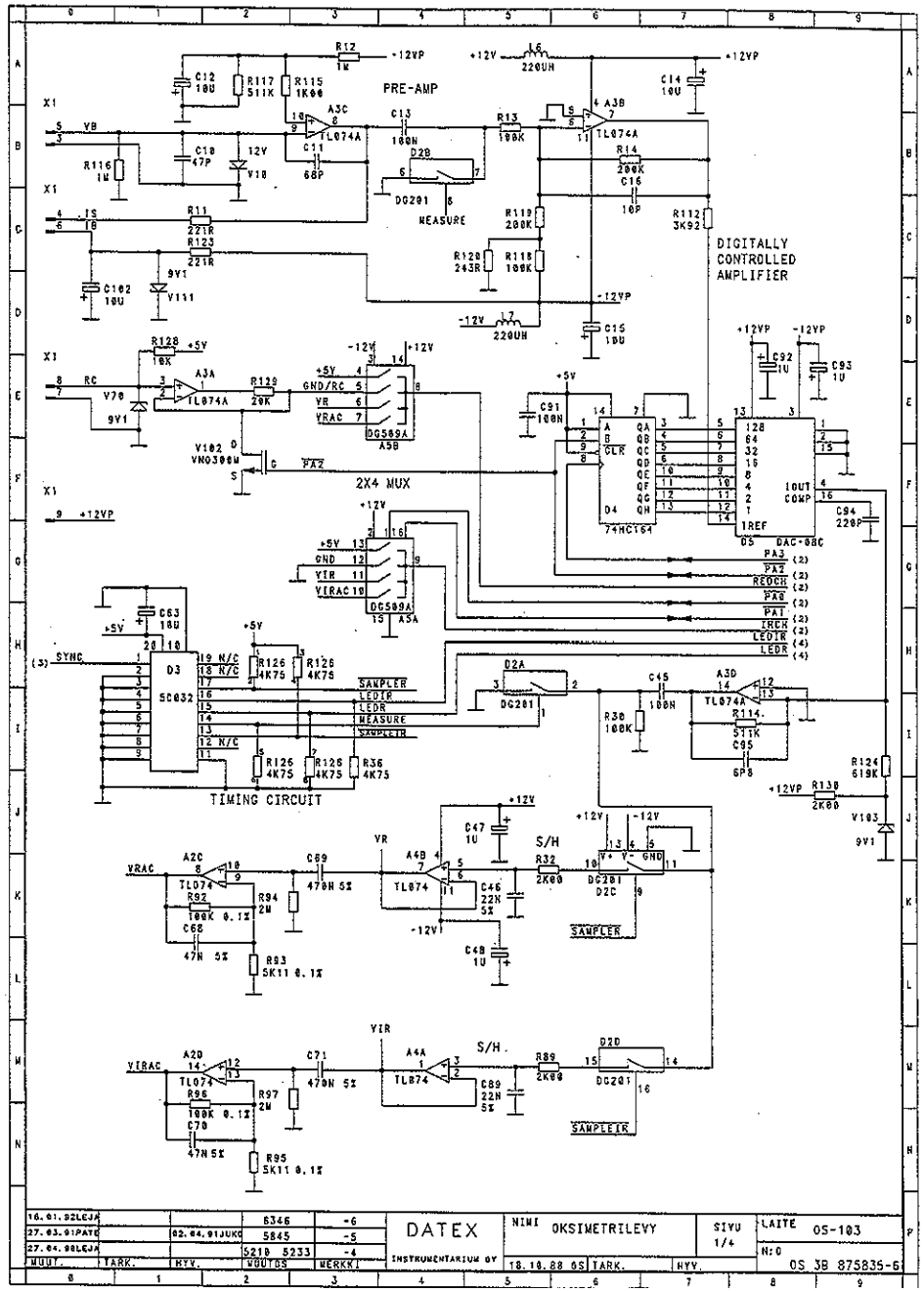
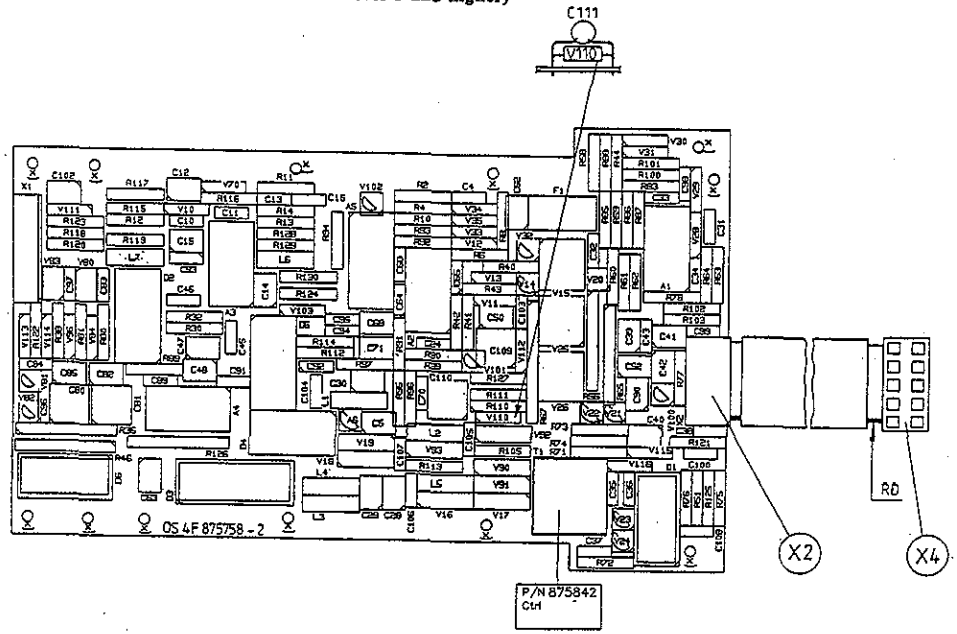
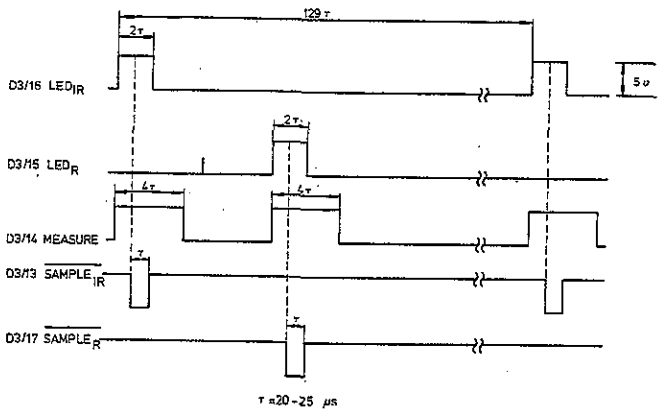


Figure 5.11 SpO_2 Measuring board parts layout, timing diagram and schematic diagram part 2 (board modification level 8 and higher)





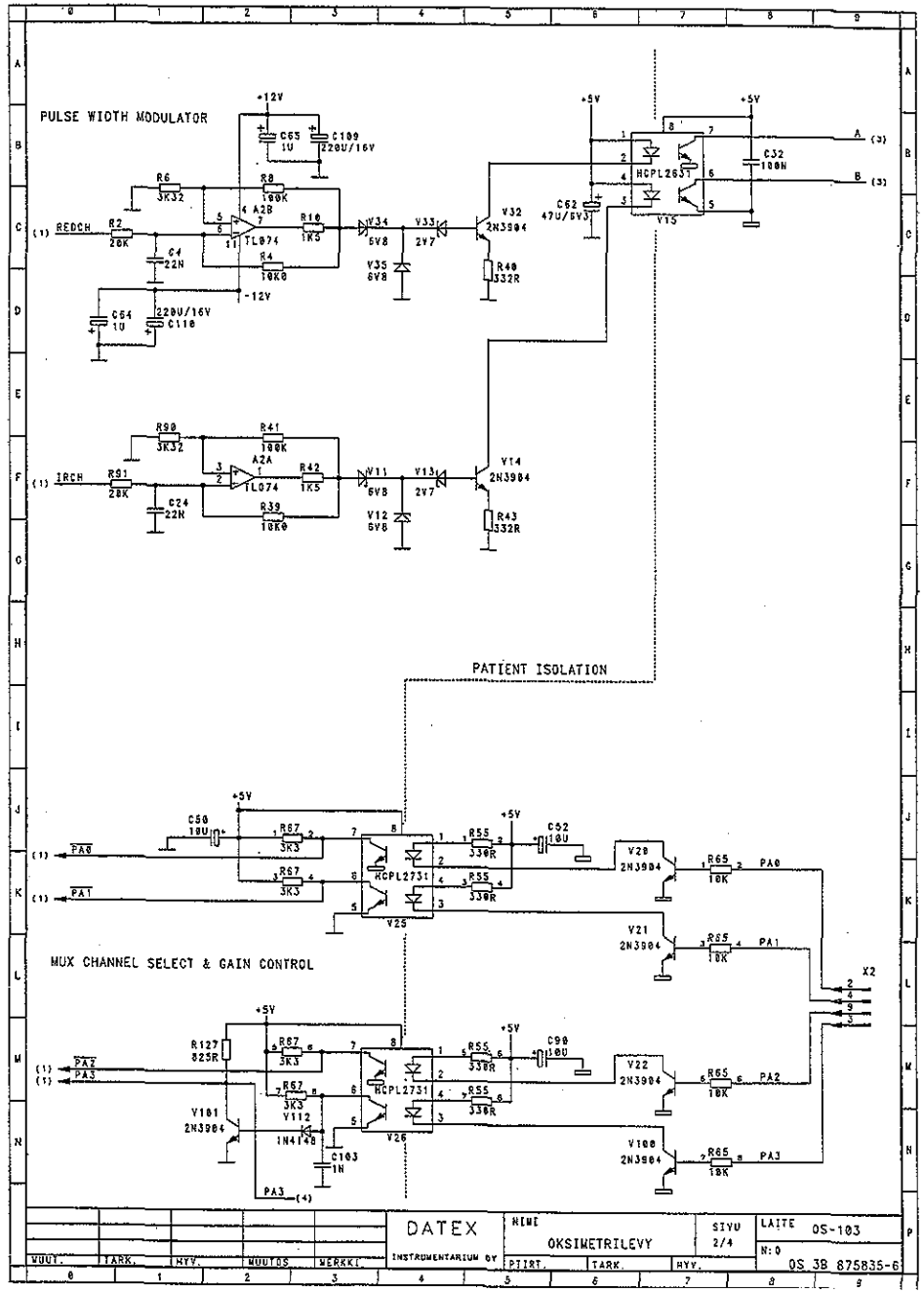
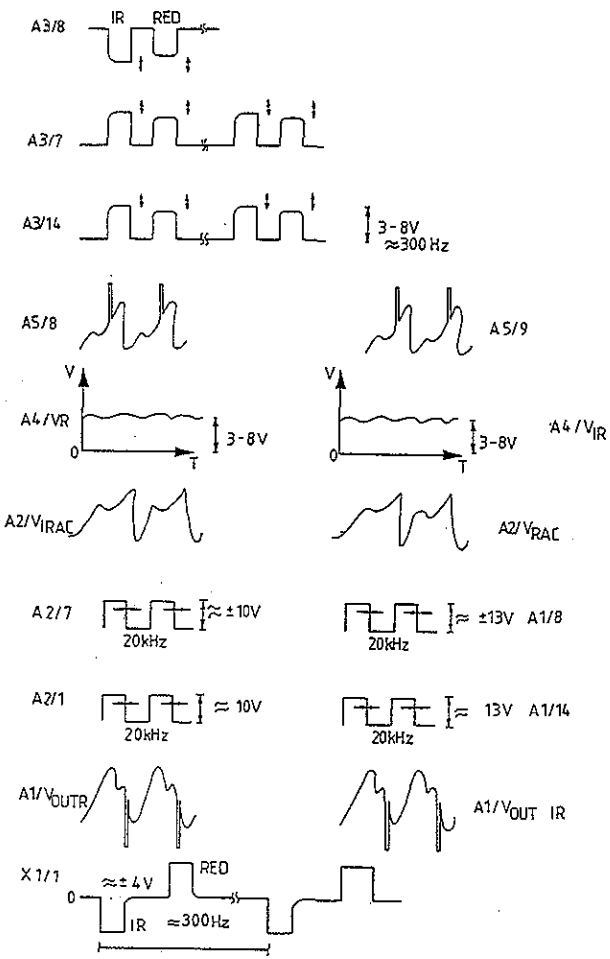


Figure 5.12 SpO_2 Measuring board signal waveforms and schematic diagram part 3 (board modification level 8 and higher)



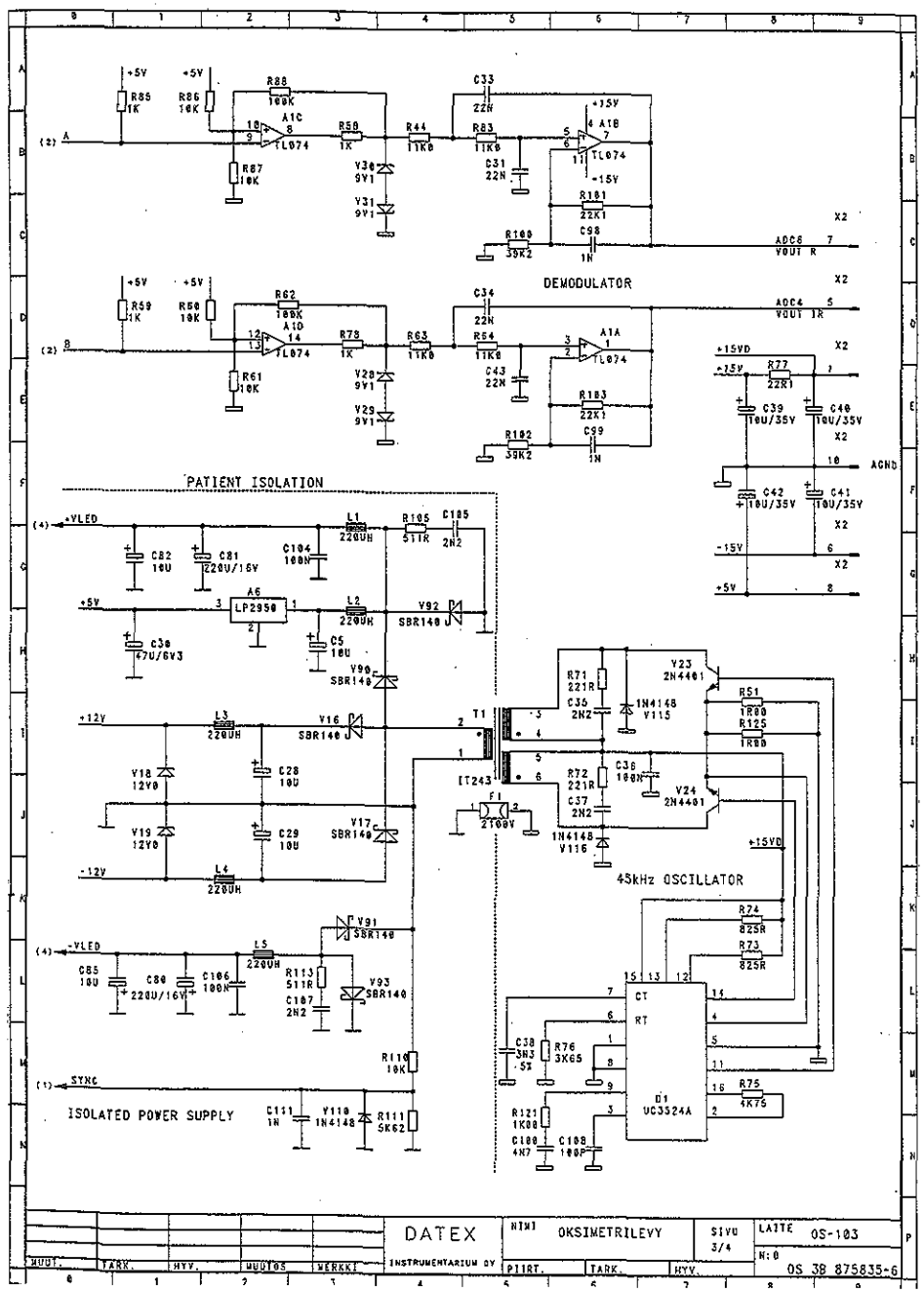
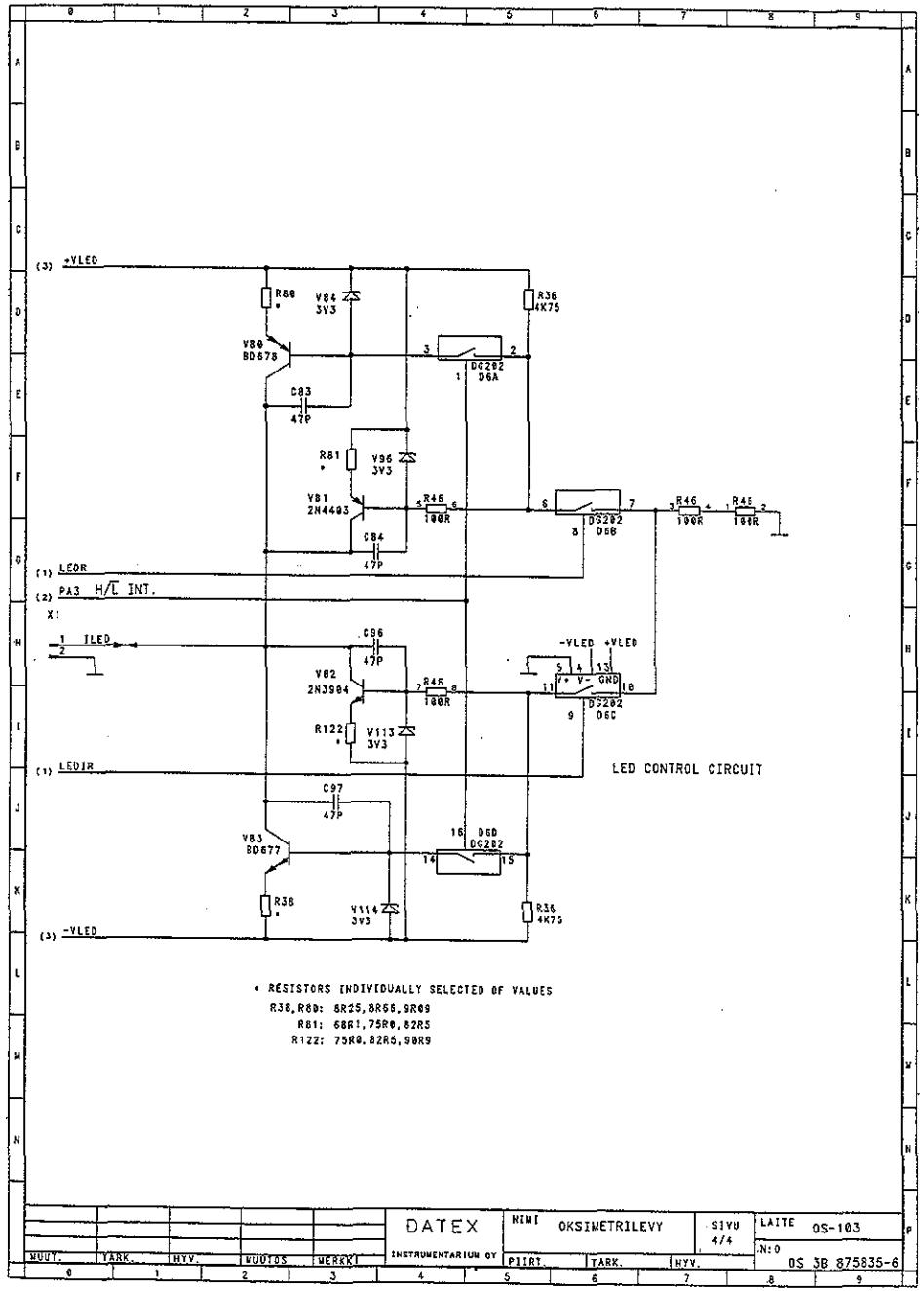


Figure 5.13 SpO_2 Measuring board schematic diagram part 4 (board modification level 8 and higher)



5.6 CPU board

Block diagram and schematic diagram part 1 **Figure 5.14**
Parts layout and schematic diagram part 2 **Figure 5.15**
Jumper configuration and schematic diagram part 3 **Figure 5.16**

Principle of operation

The CPU board contains, in addition to the 8051FA CPU and the standard EPROM, RAM and EEPROM, several analog and digital I/O functions. See the CPU board block diagram.

The CPU (D5) uses the CPU board internal bus to access most of the peripheral circuits; the on-chip peripheral ports are directly used for analog multiplexers (MUX) and serial channel 0 (ASCII computer output). The computer output is explained in Appendix A.

The three memory chips are jumper selected for 1M bit program EPROM (D1), 32 x 8 kbit low current CMOS RAM (D6) powered by the data retention voltage, and EEPROM (D4) for permanent calibration value memory. See the jumper configuration.

Analog input signals are read through the multiplexer (A3) to the A/D-converter A2.

Control signals of MUX are in port 1 on the microprocessor as follows:

P1	pins 3-5	MUX A0-A2 (both)
	pin 6	MUX enable (both)
	pin 7	MUX 0 Write (ADC)
	pin 8	MUX 1 Write (DAC)
	ADC 4	Ired signals
	ADC 6	Red signals
	DAC 2	SpO_2
	DAC 6	Ired pleth
	DAC 5	Loudspeaker volume
	DAC 7	Loudspeaker pitch

Ports on the PPI is used for as follows:

PA (output)	PB (input)	PC (low input,high output)
PA0: SpO_2 control	PB0: not used (AUX)	PC0: not used
PA1: SpO_2 control	PB1: not used (AUX)	PC1: not used
PA2: SpO_2 control	PB2: not used	PC2: not used
PA3: SpO_2 control	PB3: Test (S&A)	PC3: not used
PA4: not used	PB4: Gas freeze (S&A)	PC4: not used
PA5: not used (AUX)	PB5: CTSB (AUX)	PC5: not used
PA6: not used (AUX)	PB6: CTSA (AUX)	PC6: not used
PA7: Nurse call (AUX)	PB7: not used	PC7: Alarm LED

When a key is pressed (short-circuit) keyboard scanner (D9) interrupts the microprocessor and this reads from the scanner which key was pressed.

The microprocessor's RS-232 is connected to Serial & Analog I/O connector (computer output). Duart channel A is connected to Aux I/O connector (graphic output) and duart channel B is used for communication between the microprocessor and the ACX measuring board.

Real time clock (D16) is powered by a 3.4 V lithium battery G1. Oscillator frequency of the clock is adjusted with trimmer capacitor C49.

Software features are described in the Operator's Manual. Main differences between software revisions are described in Section 3.4.

CAUTION: The board contains a lithium battery. Danger of explosion if the battery is incorrectly replaced. Replace only with same or equivalent type recommended by Datex. Discard used batteries according to manufacturer's instruction.

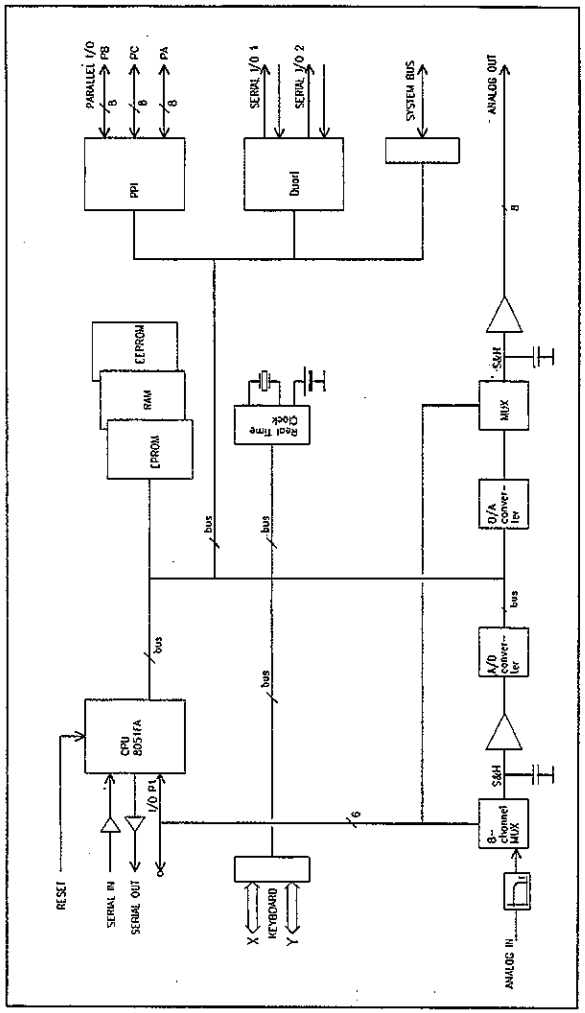
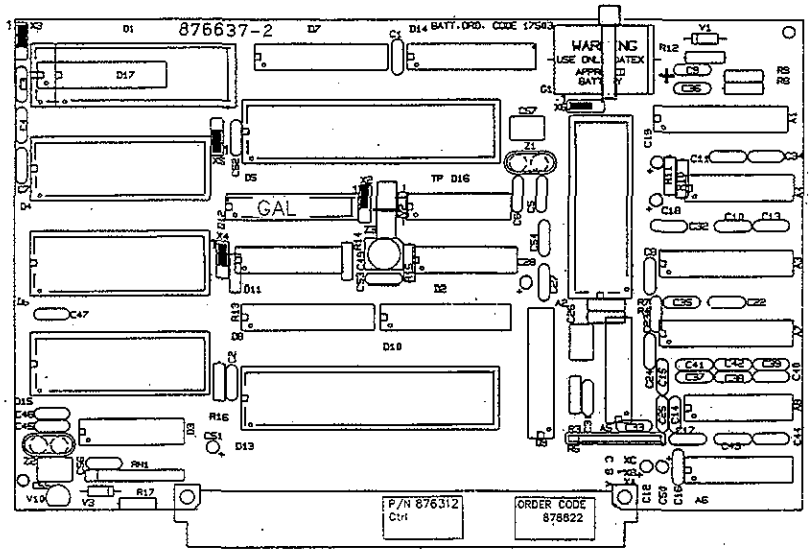


Figure 5.14 CPU board block diagram and schematic diagram part 1 (board modification level 8 and higher)

Figure 5.15 ***CPU board parts layout and schematic diagram part 2 (board modification level 8 and higher)***



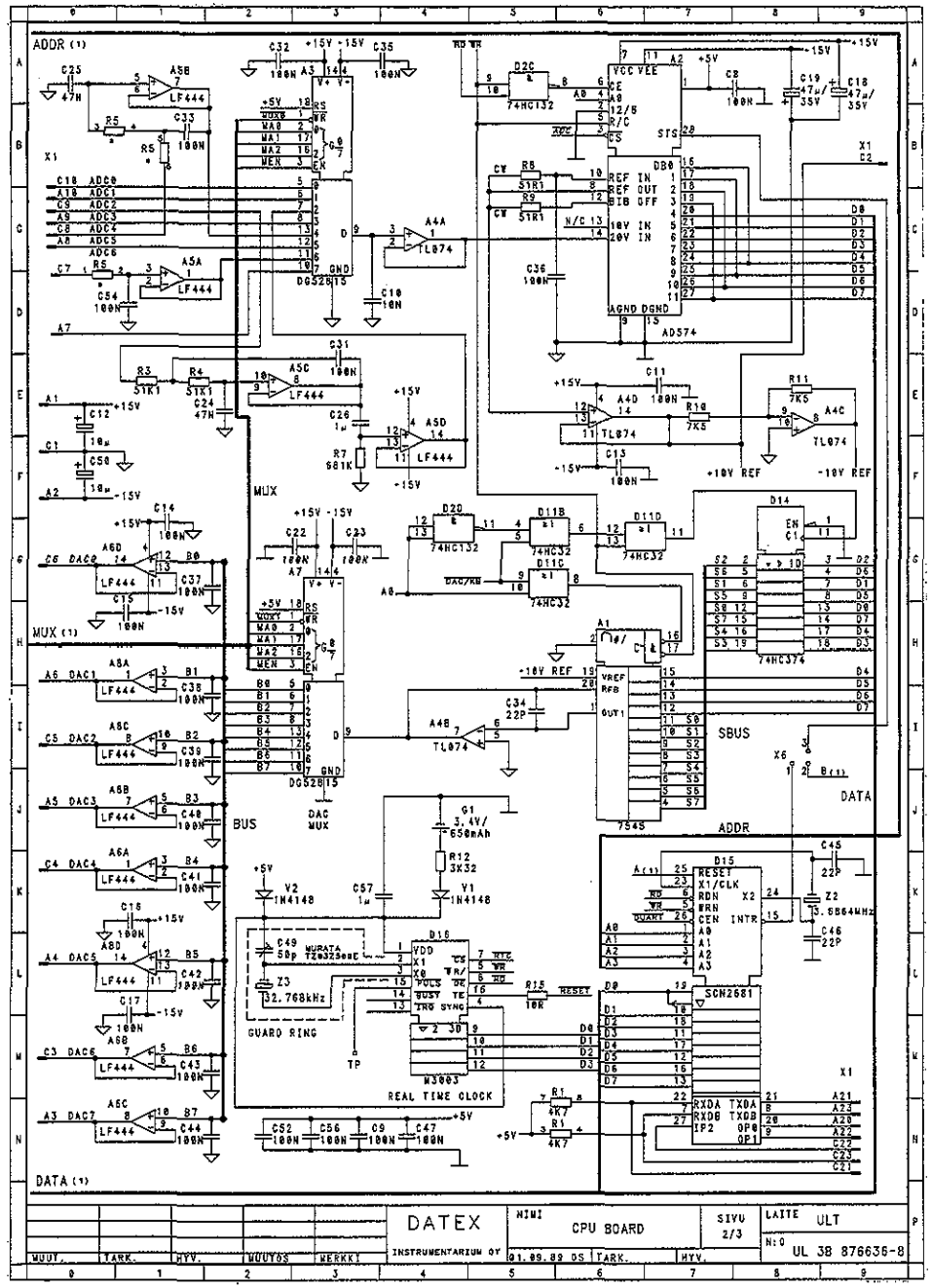
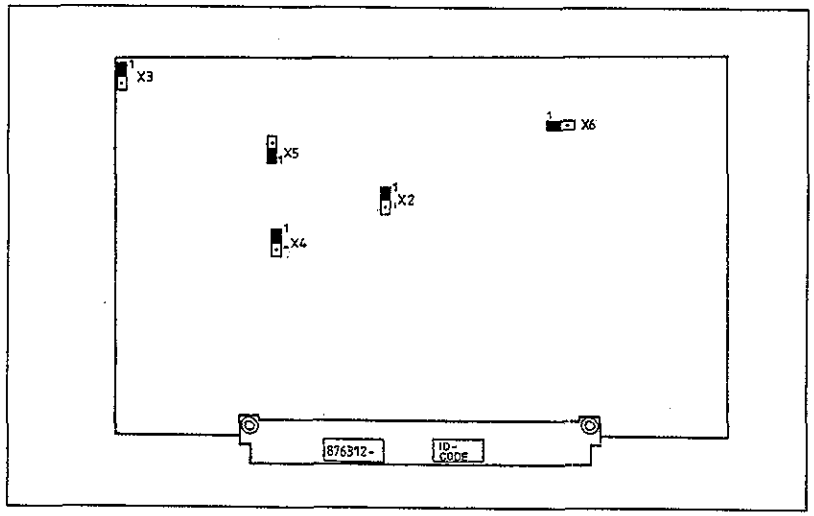


Figure 5.16 CPU board jumper configuration and schematic diagram part 3 (board modification level 8 and higher)

CONNECTOR	JUMPER	MEMORY TYPE
X2, X4	1-2	D6 : 32k x 8 RAM
	2-3	D6 : 8k x 8 RAM
X3	1-2	D1 : 512k, 1M EPROM
	2-3	D1 : 2M, 4M EPROM
X5	1-2	D4 : E2PROM, RAM
	2-3	D4 : EPROM
X6	1-2	Norm
	2-3	Test



MONITOR	Place of the jumpers in X2	X3	X4	X5	X6
OSE-123 VERSION 00	2-3	1-2	1-2	1-2	1-2
OSE-123 VERSION 01	1-2	1-2	1-2	1-2	1-2
SC-123	1-2	1-2	1-2	1-2	1-2
SCO-123	1-2	1-2	1-2	1-2	1-2
WBW-100	1-2	1-2	1-2	1-2	1-2
ULT	1-2	1-2	1-2	1-2	1-2
CH VERSIO 00	2-3	1-2	1-2	1-2	1-2
CG VERSIO 00	2-3	1-2	1-2	1-2	1-2
CH VERSIO 01	1-2				
CG VERSIO 01	1-2				
CMO	2-3	1-2	1-2	1-2	1-2
CTO	2-3	1-2	1-2	1-2	1-2

MONITOR	Resistor network R5
OSE-123 VERSION 00	4 x 4k7
OSE-123 VERSION 01	4 x 4k7
SC-123	4 x 4k7
SCO-123	4 x 4k7
WBW-100	4 x 4k7
ULT	4 x 4k7
CH	4 x 47k
CG	4 x 47k
CMO	4 x 47k
CTO	4 x 47k

DATEX INSTRUMENTARIUM OY
NIMI: CPU BOARD
SIVU 3/3
LAITE ULT
N:o UL 3B 876636-8

5.7 Video control board

Block diagram	**Figure 5.17**
Parts layout and timing diagram	**Figure 5.18**
Schematic diagram	**Figure 5.19**

Principle of operation

The video control board (see the block diagram) is based on an LSI graphics display processor GDP (D4), which accepts commands from the CPU via the system bus and converts them to operations on a bit image in the video RAM memory. The video RAM is then continuously scanned by addressing logic and a video shift register to produce a 24 MHz dot stream that forms the screen image. The display processor adds the synchronization information, which is separated into vertical (50 Hz) and horizontal (15 kHz) components before being sent to the CRT unit. The signals are also combined into a composite video signal, which is output to the rear panel.

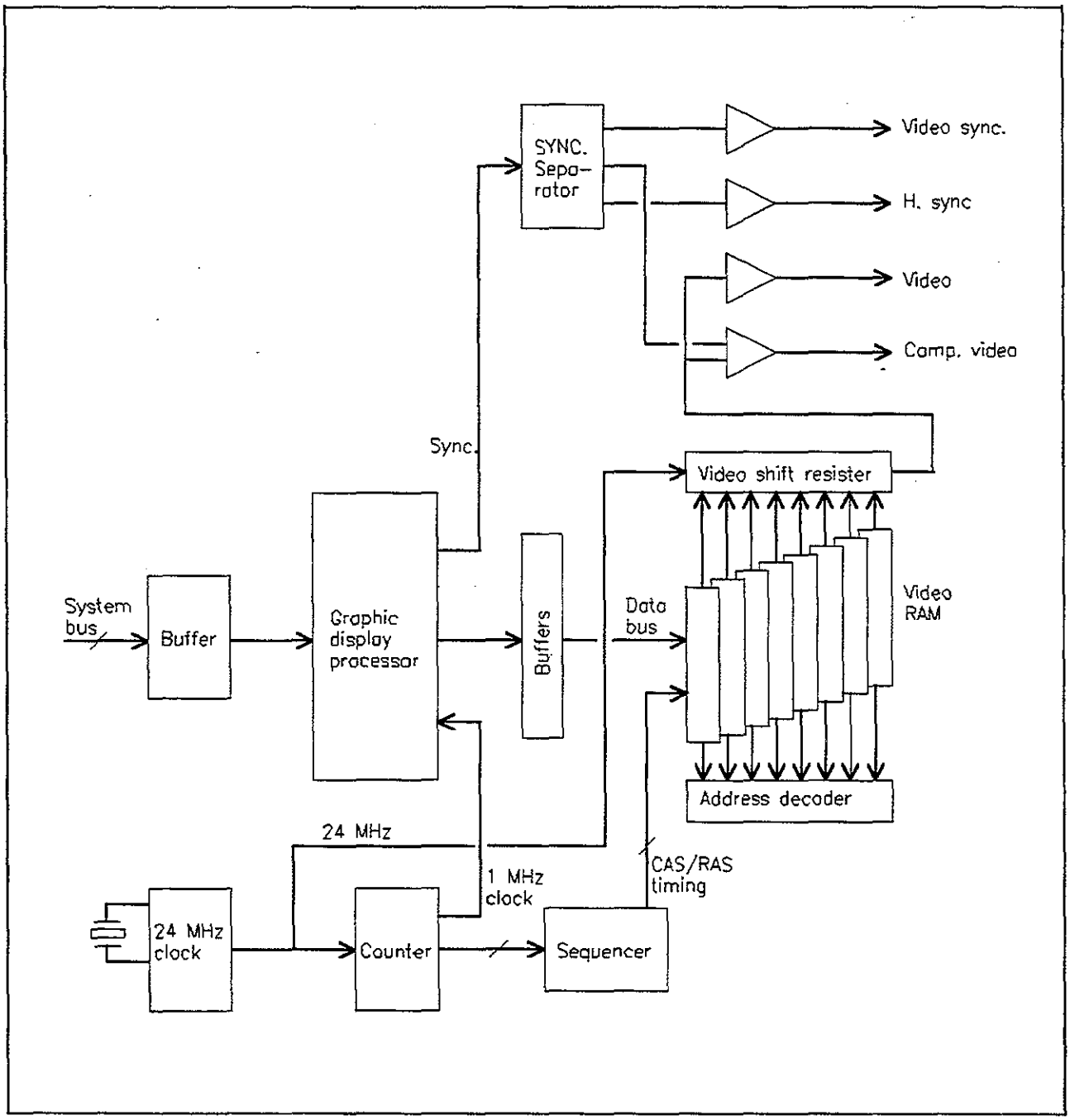


Figure 5.17 Video control board block diagram

Figure 5.18 Video control board parts layout and timing diagram (board modification level 8 and higher)

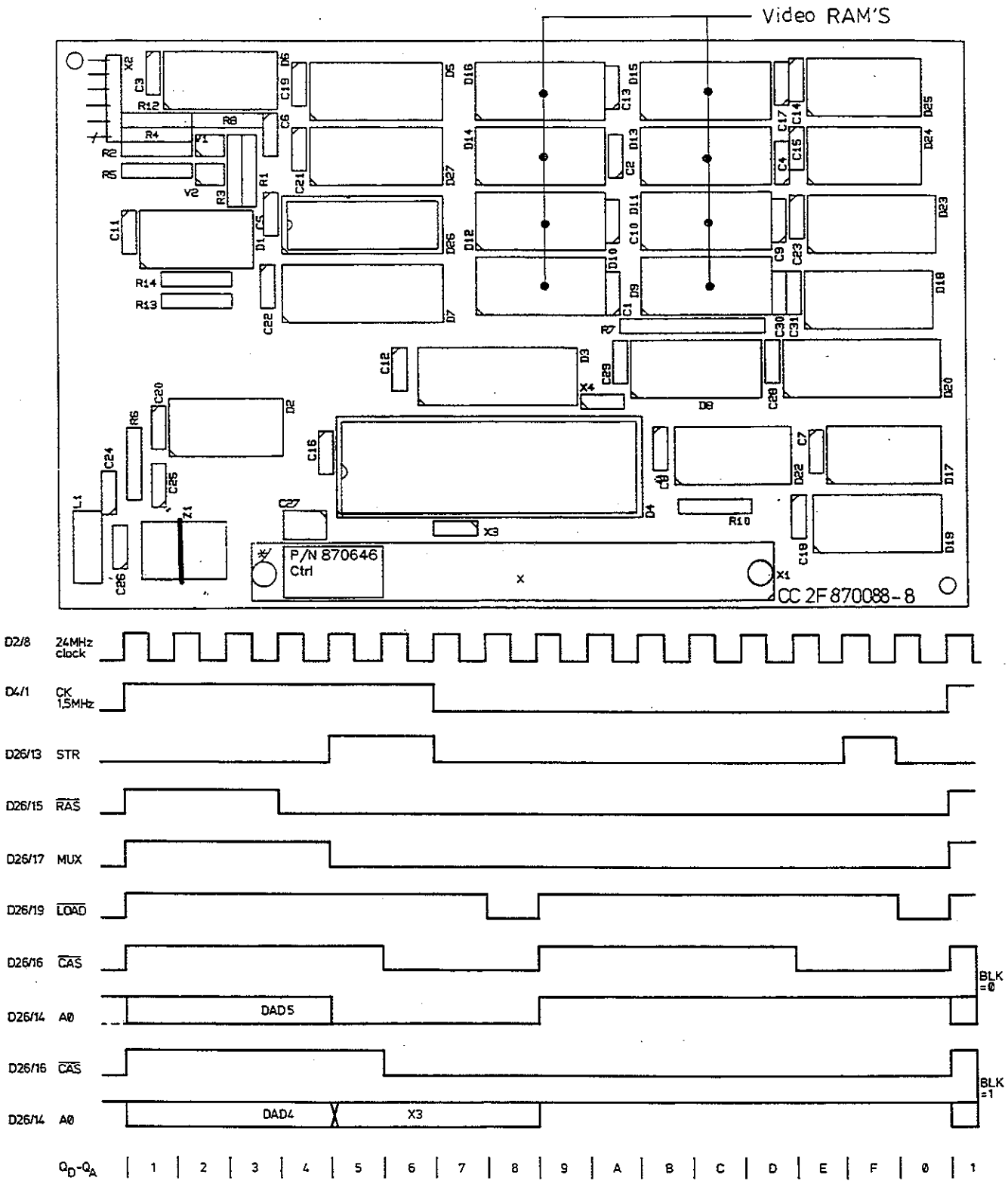
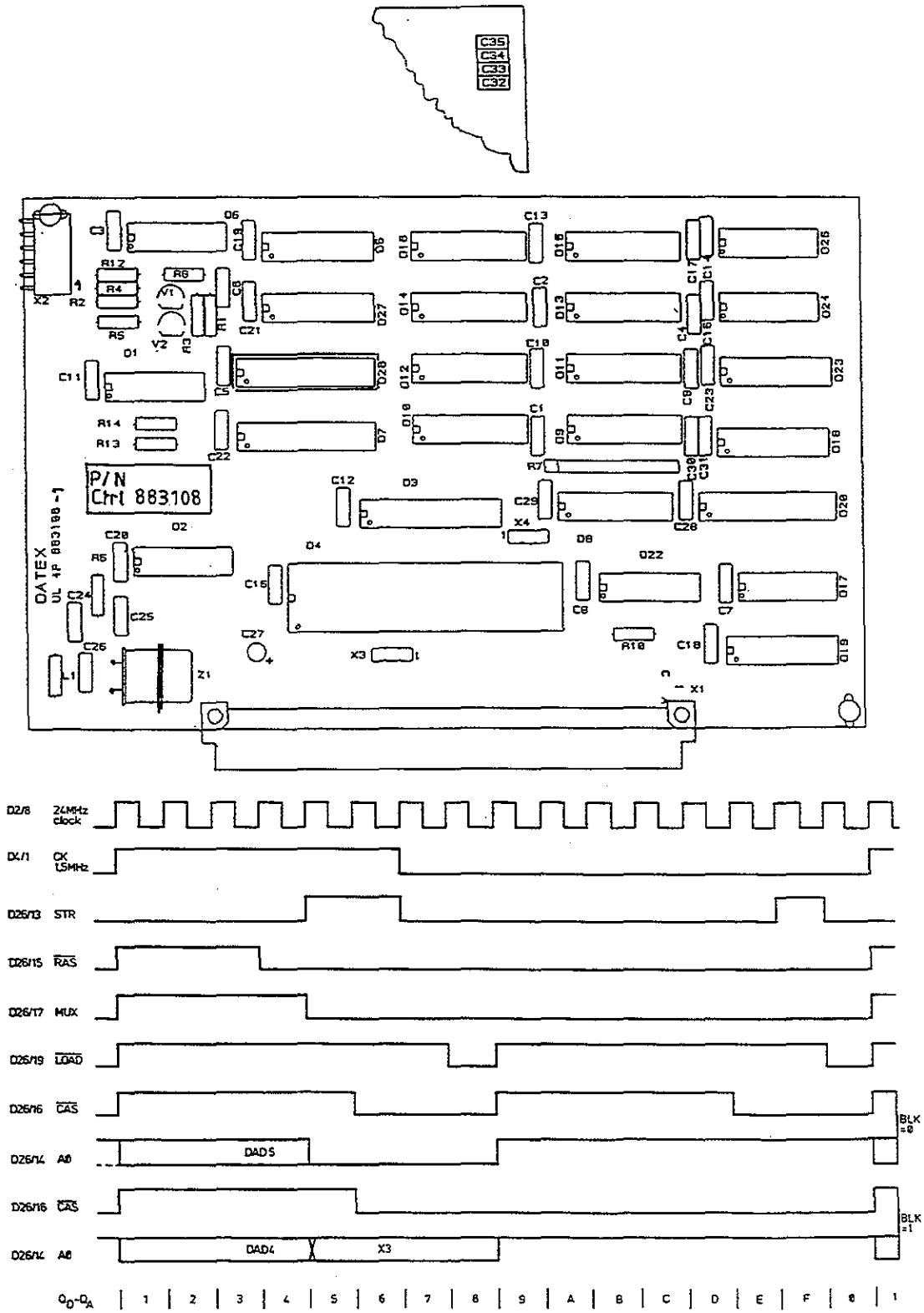
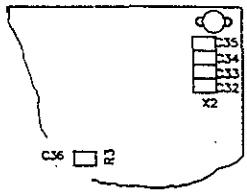


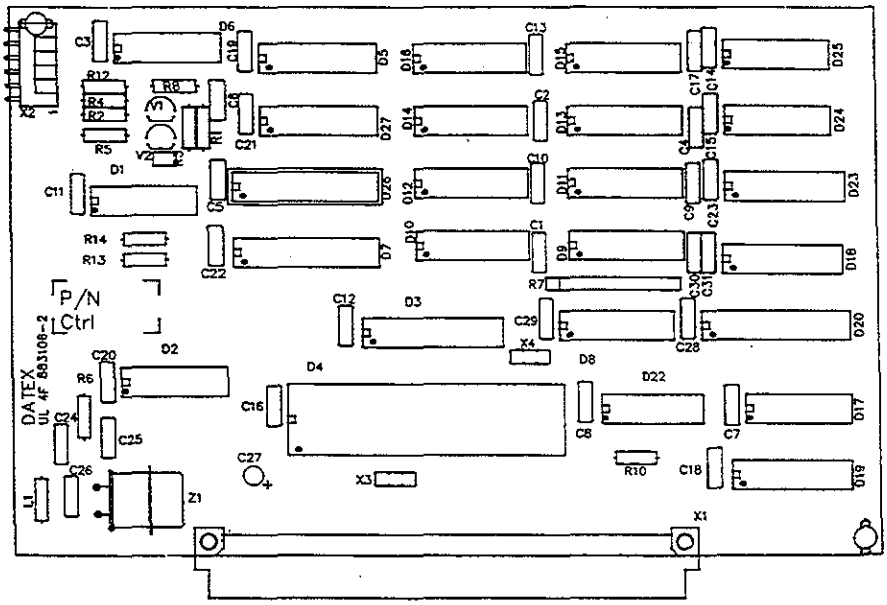
Figure 5.18 Video control board parts layout and timing diagram



VIDEO CONTROL BOARD
TIMING DIAGRAM

Figure 5.18 Video control board parts layout and timing diagram (Board modification level 3 and higher)





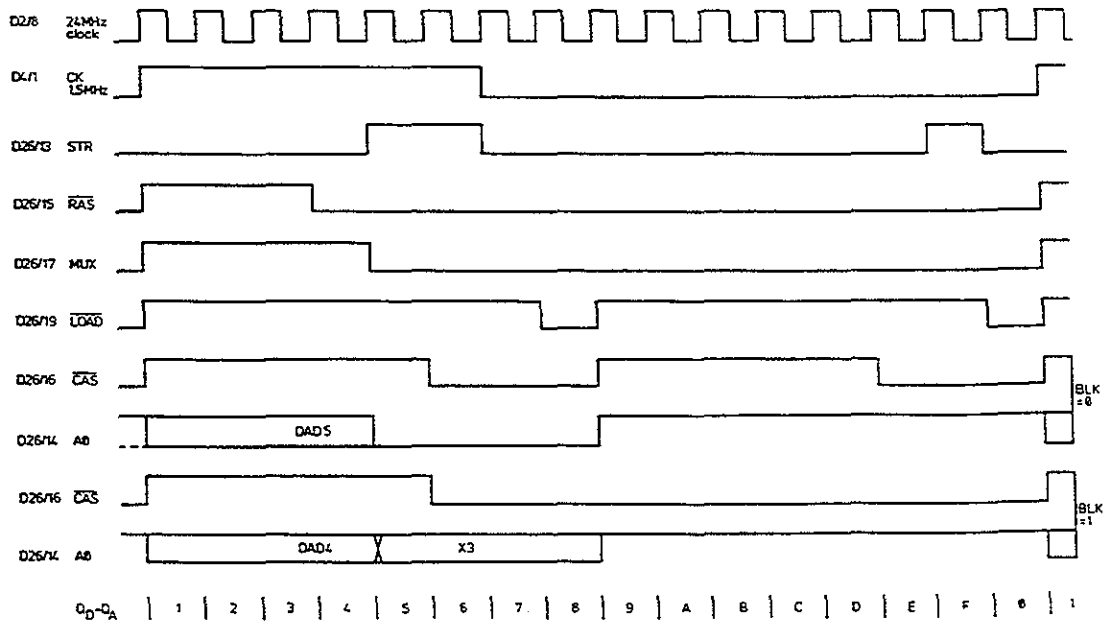


Figure 5.19 Video control board schematic diagram (board modification level 8 and higher)

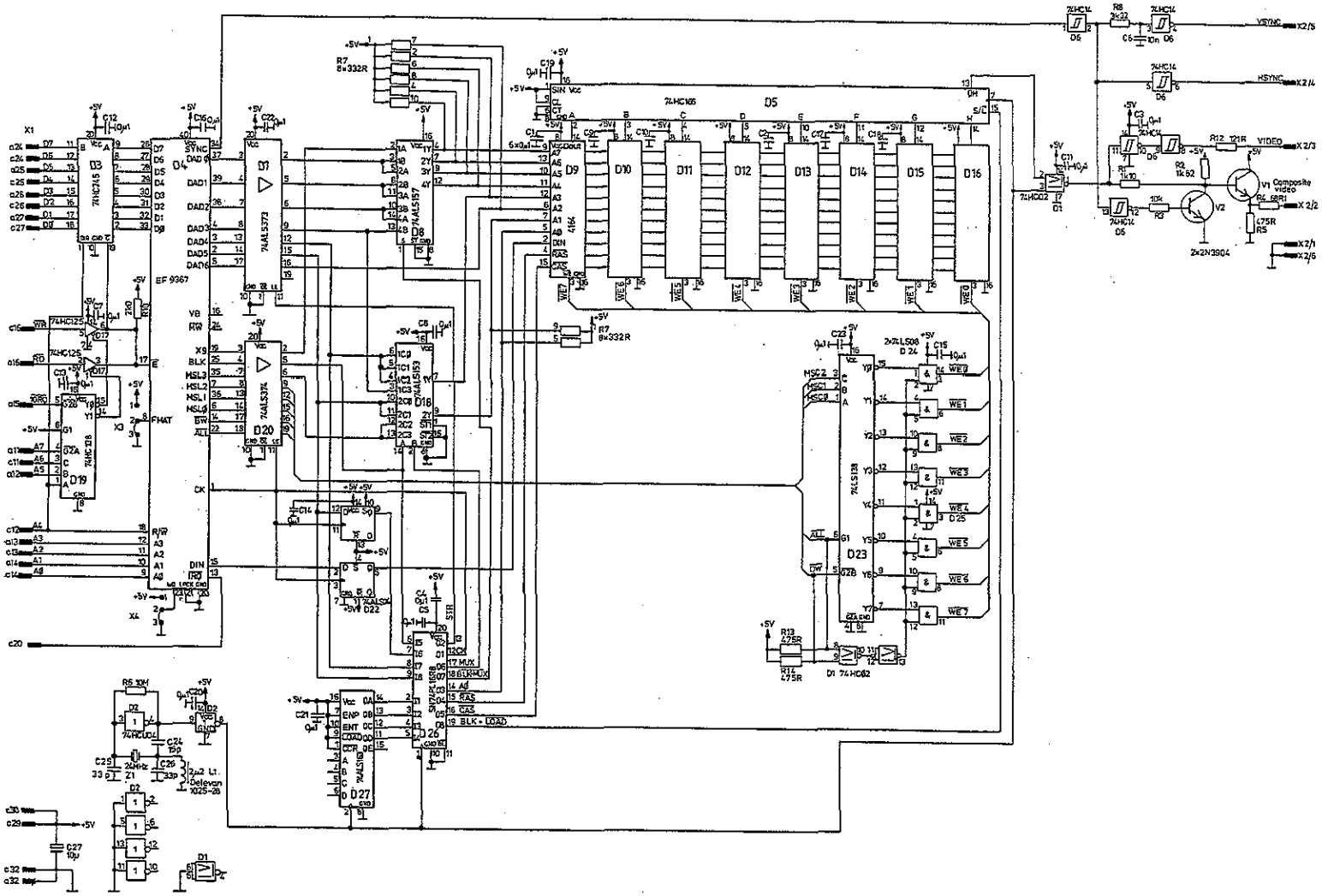


Figure 5.19 Video control board schematic diagram

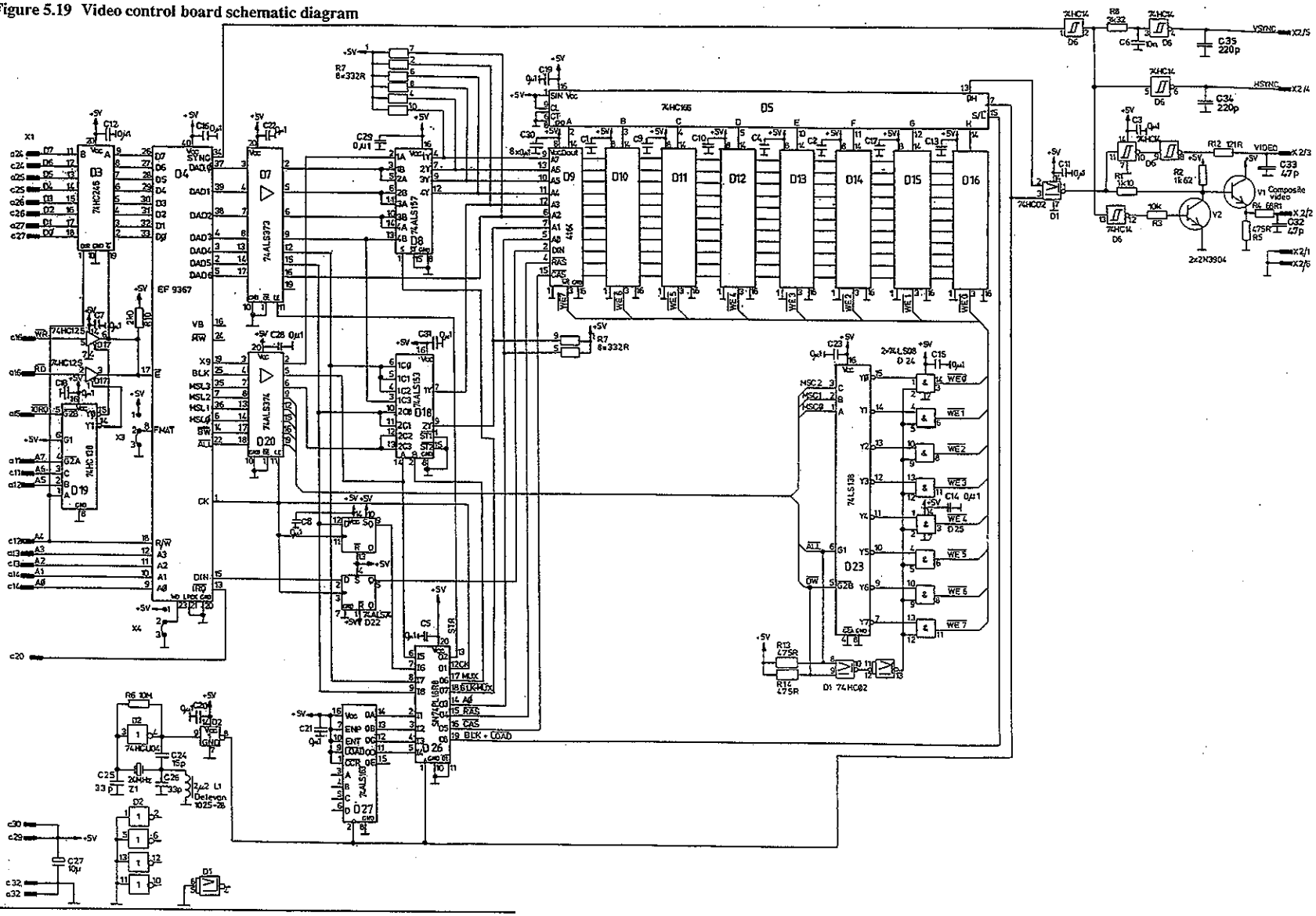
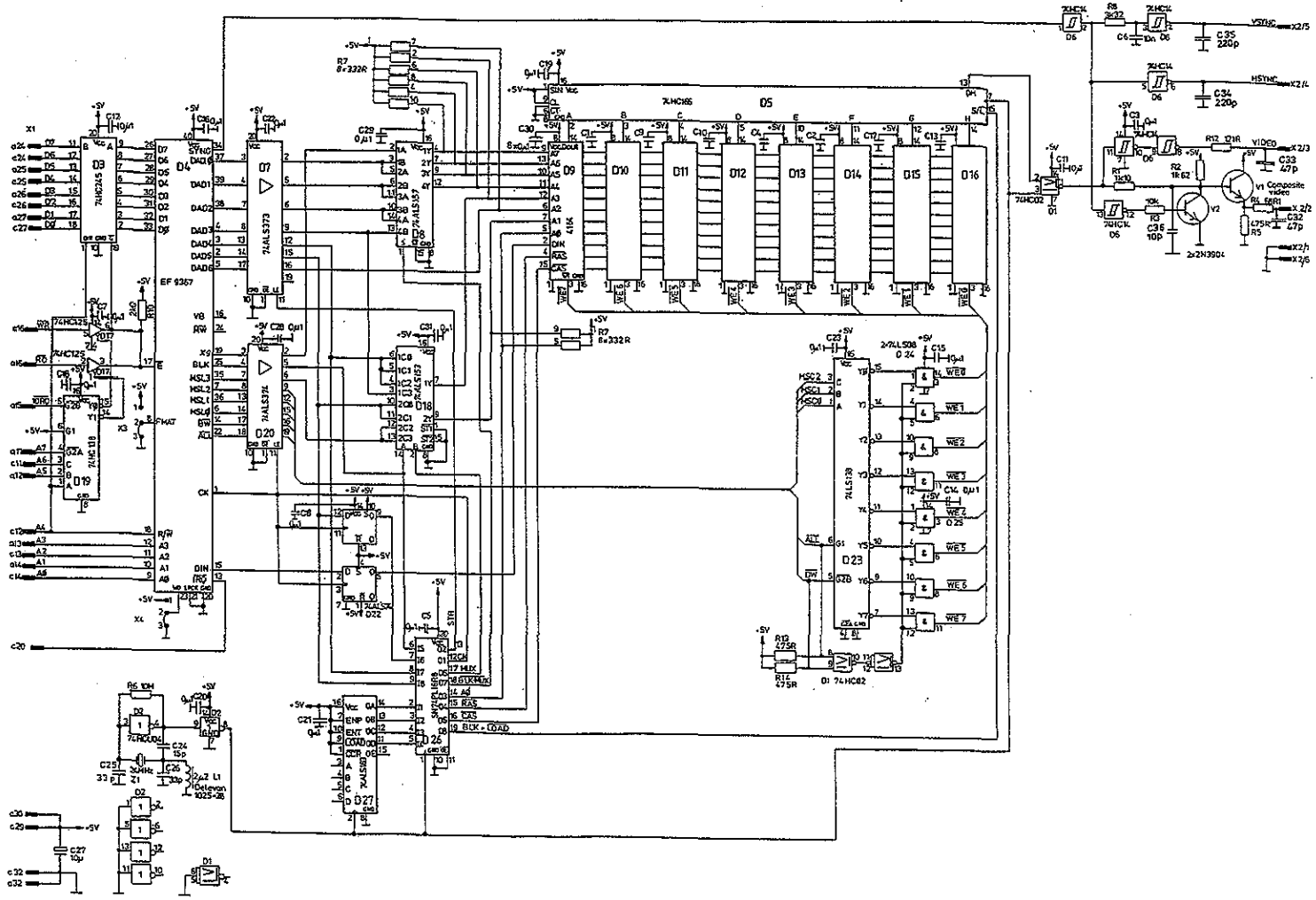


Figure 5.19 Video control board schematic diagram (Board modification level 3 and higher)



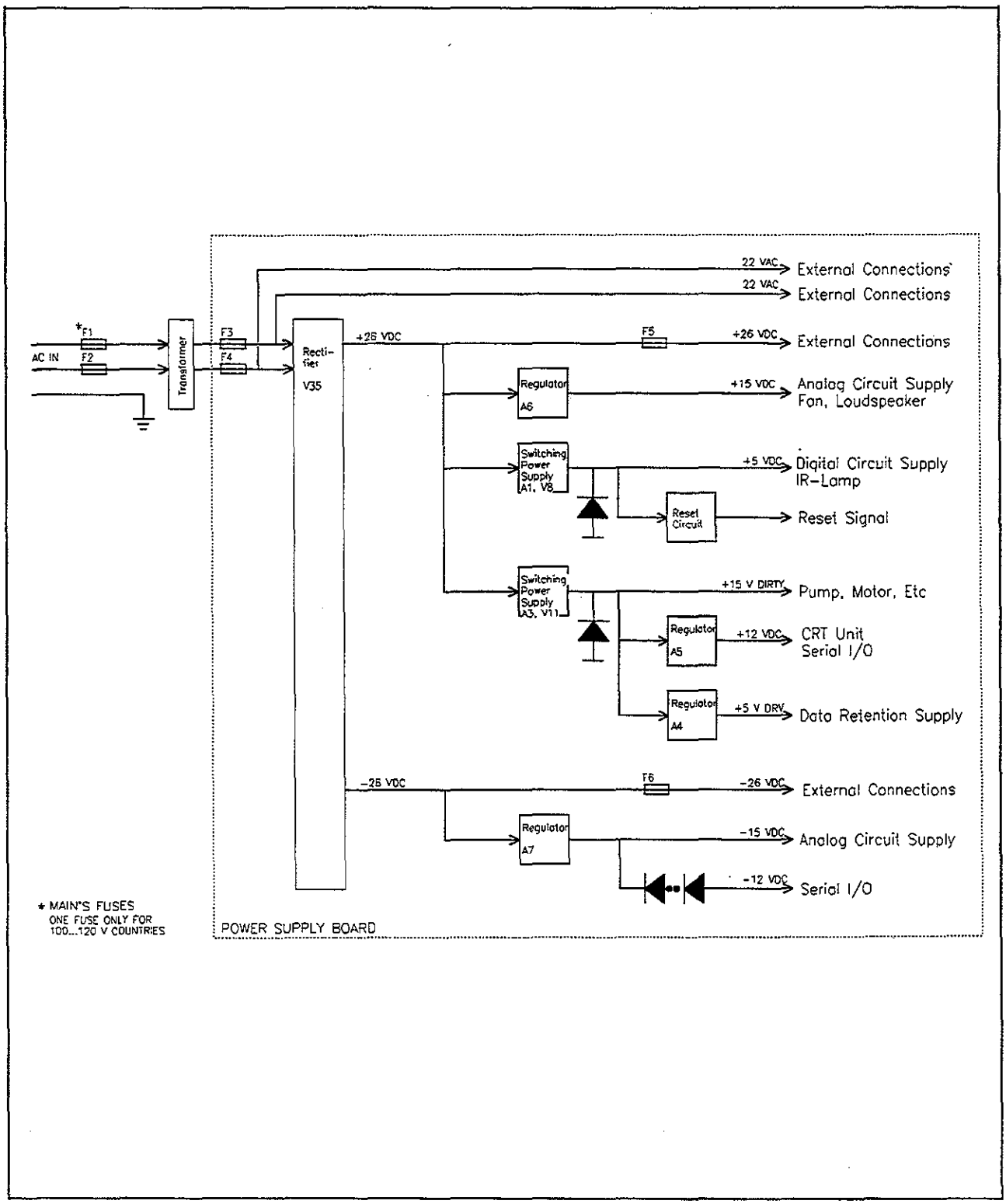
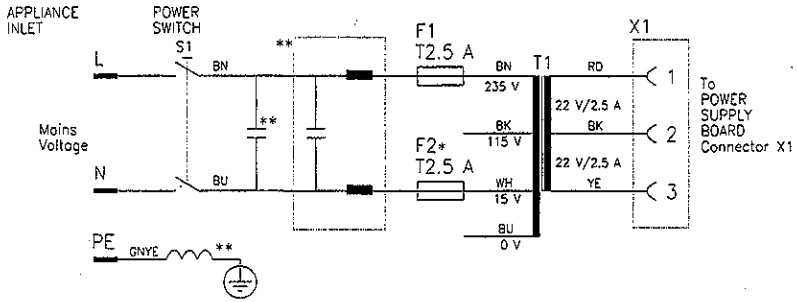


Figure 5.20 Power supply board block diagram

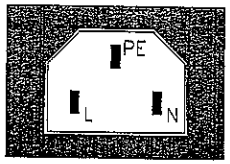
Figure 5.22a Transformer diagram and schematic diagram part 3 (board modification level 3 and higher)



* Fuse F2 not in adaptations 27, 28, and 29.

** Line voltage filter, High voltage capacitor, and Ground choke are only in adaptations 33 (except ULT–1 and S models).

If no polarized mains plug and mains socket outlet system is used, position of line (L) and neutral (N) in the appliance inlet depends on the position of mains plug set into the mains socket outlet.



The contact positions of the appliance inlet by looking at the engagement face of the appliance inlet.

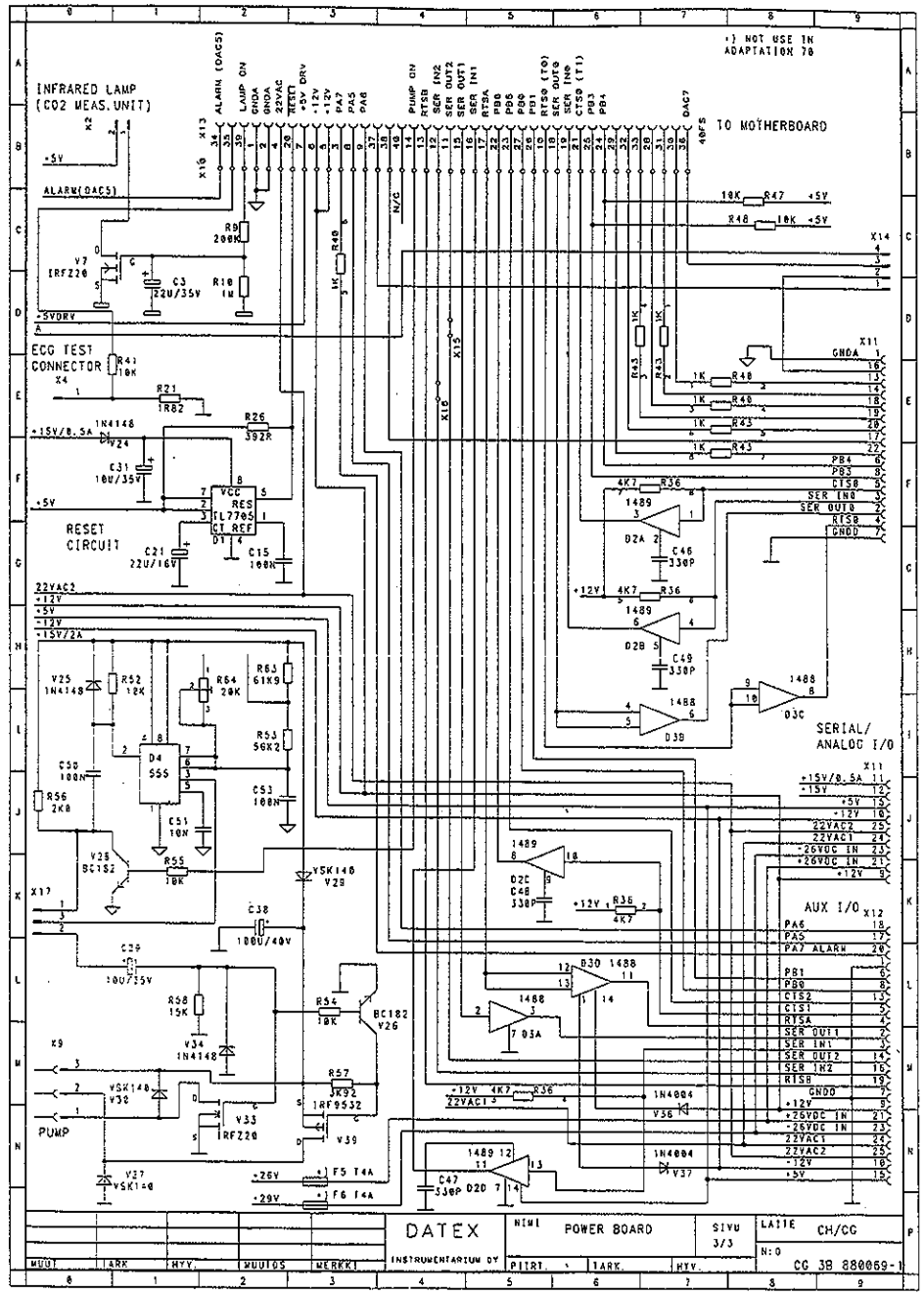
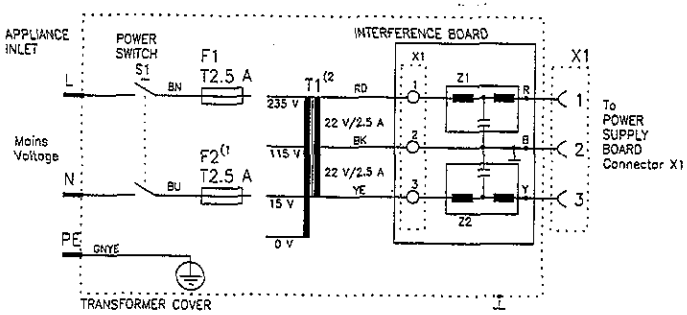


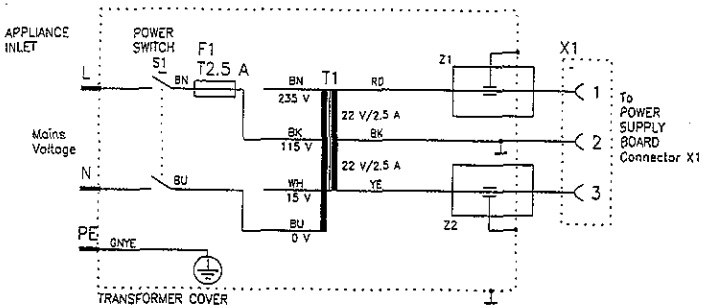
Figure 5.22a Transformer diagram and schematic diagram part 3 (board modification level 3 and higher)



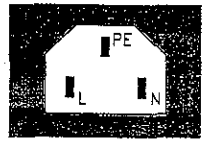
ALL ADAPTATIONS EXCEPT 27

1) Fuse F2 not in adaptations 28 and 29.
2) Primary wiring table

ADAPTATIONS	WIRING
23, 33, 43	BN to 235 V, BU to 0 V
28, 29	BN to 115 V, BU to 0 V
31	BN to 115 V, BU to 15 V

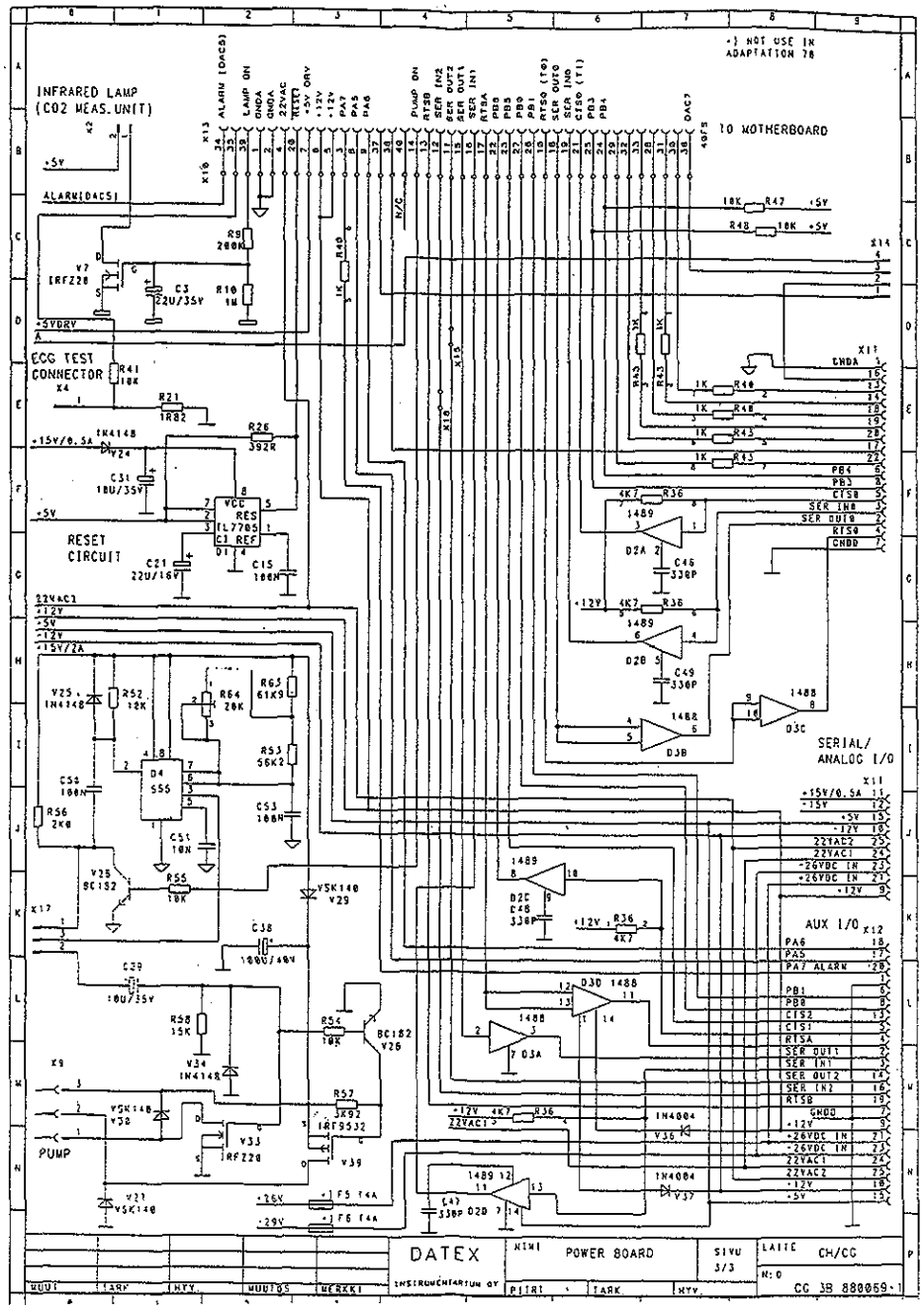


ADAPTATION 27



If no polarized mains plug and mains socket outlet system is used, position of line (L) and neutral (N) in the appliance inlet depends on the position of mains plug set into the mains socket outlet.

The contact positions of the appliance inlet on rear panel looking at the engagement face of the appliance inlet.

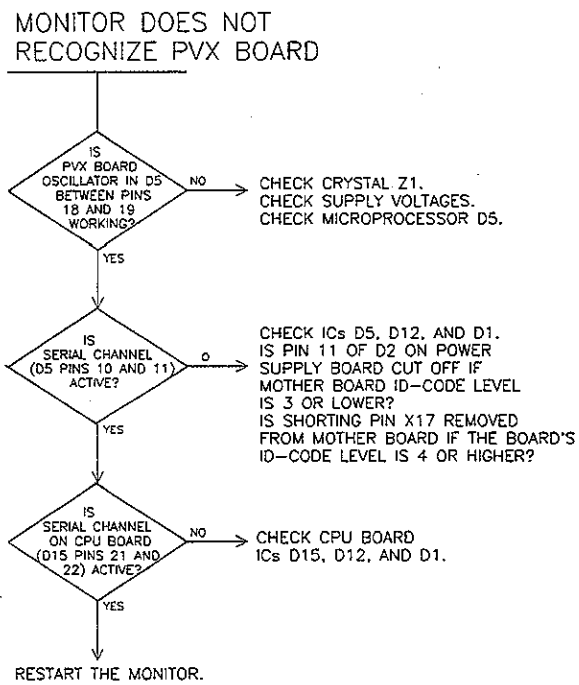


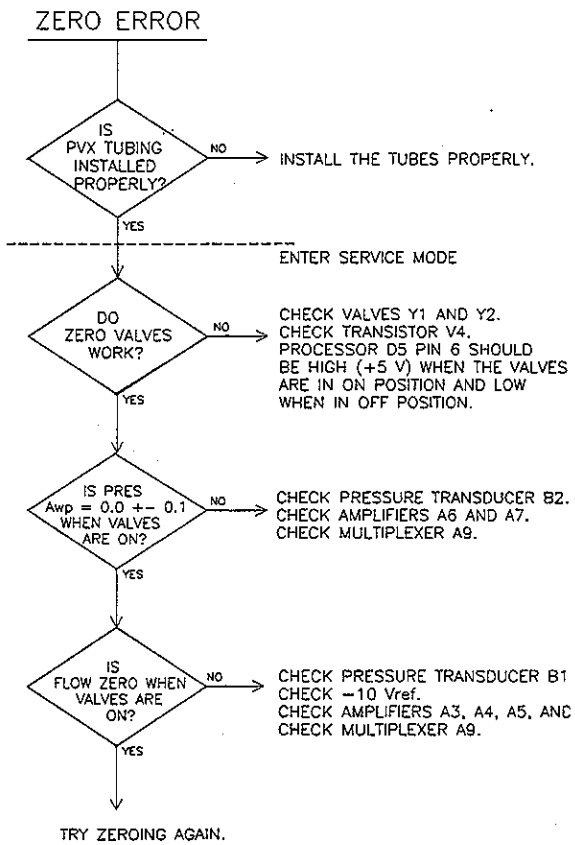
6.4.11 PVX board troubleshooting

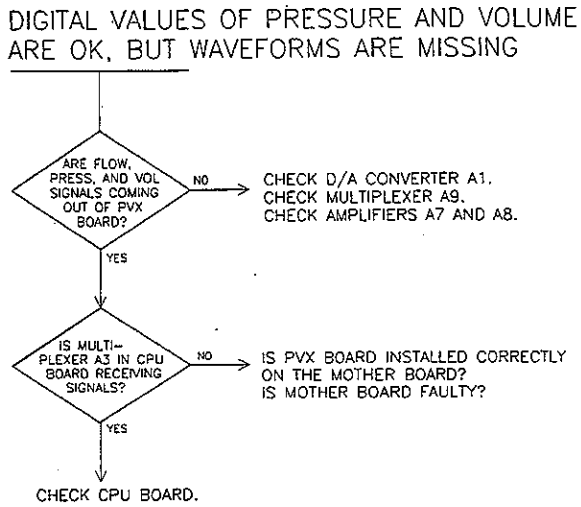
See the following flow charts to troubleshoot the PVX board.

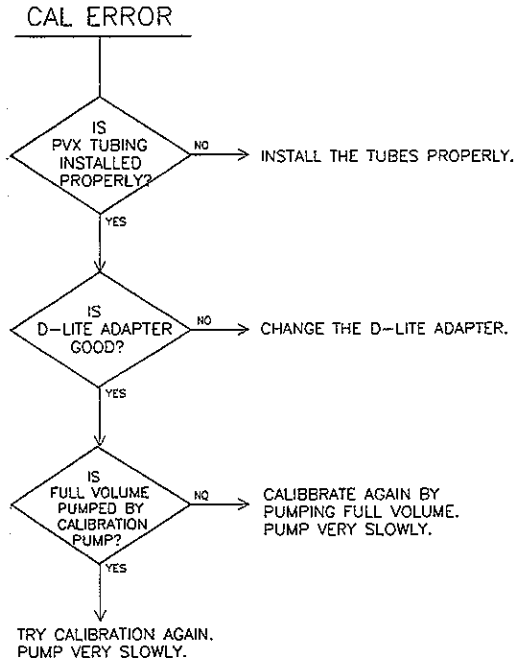
NOTE: Pressure transducers B1 and B2, and EEPROM D4 are replaced only at the factory.

NOTE: Never apply overpressure or negative pressure of more than 300 cmH_2O to the flow and volume tubing.


MONITOR DOES NOT RECOGNIZE PVX BOARD
IS PVX BOARD OSCILLATOR IN D5 BETWEEN PINS 18 AND 19 WORKING?
NO
CHECK CRYSTAL Z1.
CHECK SUPPLY VOLTAGES.
CHECK MICROPROCESSOR D5.
YES
IS SERIAL CHANNEL (D5 PINS 10 AND 11) ACTIVE?
0
CHECK ICs D5, D12, AND D1.
IS PIN 11 OF D2 ON POWER SUPPLY BOARD CUT OFF IF MOTHER BOARD ID-CODE LEVEL IS 3 OR LOWER?
IS SHORTING PIN X17 REMOVED FROM MOTHER BOARD IF THE BOARD'S ID-CODE LEVEL IS 4 OR HIGHER?
YES
IS SERIAL CHANNEL ON CPU BOARD (D15 PINS 21 AND 22) ACTIVE?
NO
CHECK CPU BOARD
ICs D15, D12, AND D1.
YES
RESTART THE MONITOR.


ZERO ERROR
IS PVX TUBING INSTALLED PROPERLY?
NO
INSTALL THE TUBES PROPERLY.
YES
ENTER SERVICE MODE
DO ZERO VALVES WORK?
NO
CHECK VALVES Y1 AND Y2.
CHECK TRANSISTOR V4.
PROCESSOR D5 PIN 6 SHOULD BE HIGH (+5 V) WHEN THE VALVES ARE IN ON POSITION AND LOW WHEN IN OFF POSITION.
YES
IS PRES Awp = 0.0 +- 0.1 WHEN VALVES ARE ON?
NO
CHECK PRESSURE TRANSDUCER B2.
CHECK AMPLIFIERS A6 AND A7.
CHECK MULTIPLEXER A9.
YES
IS FLOW ZERO WHEN VALVES ARE ON?
NO
CHECK PRESSURE TRANSDUCER B1
CHECK -10 Vref.
CHECK AMPLIFIERS A3, A4, A5, AND
CHECK MULTIPLEXER A9.
YES
TRY ZEROING AGAIN.


DIGITAL VALUES OF PRESSURE AND VOLUME ARE OK, BUT WAVEFORMS ARE MISSING
ARE FLOW, PRESS, AND VOL SIGNALS COMING OUT OF PVX BOARD?
NO
CHECK D/A CONVERTER A1.
CHECK MULTIPLEXER A9.
CHECK AMPLIFIERS A7 AND A8.
YES
IS MULTI-PLEXER A3 IN CPU BOARD RECEIVING SIGNALS?
NO
IS PVX BOARD INSTALLED CORRECTLY ON THE MOTHER BOARD?
IS MOTHER BOARD FAULTY?
YES
CHECK CPU BOARD.



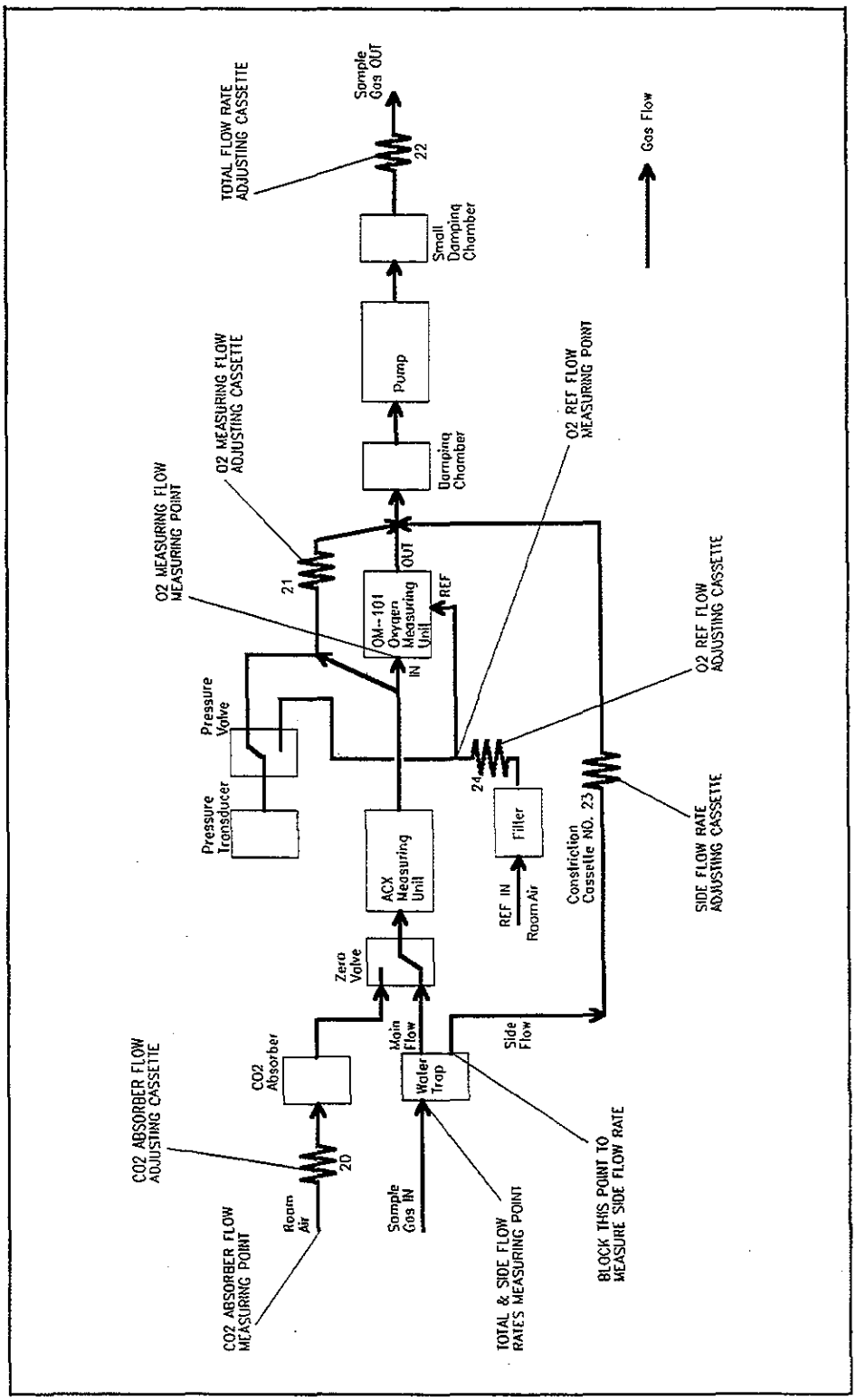
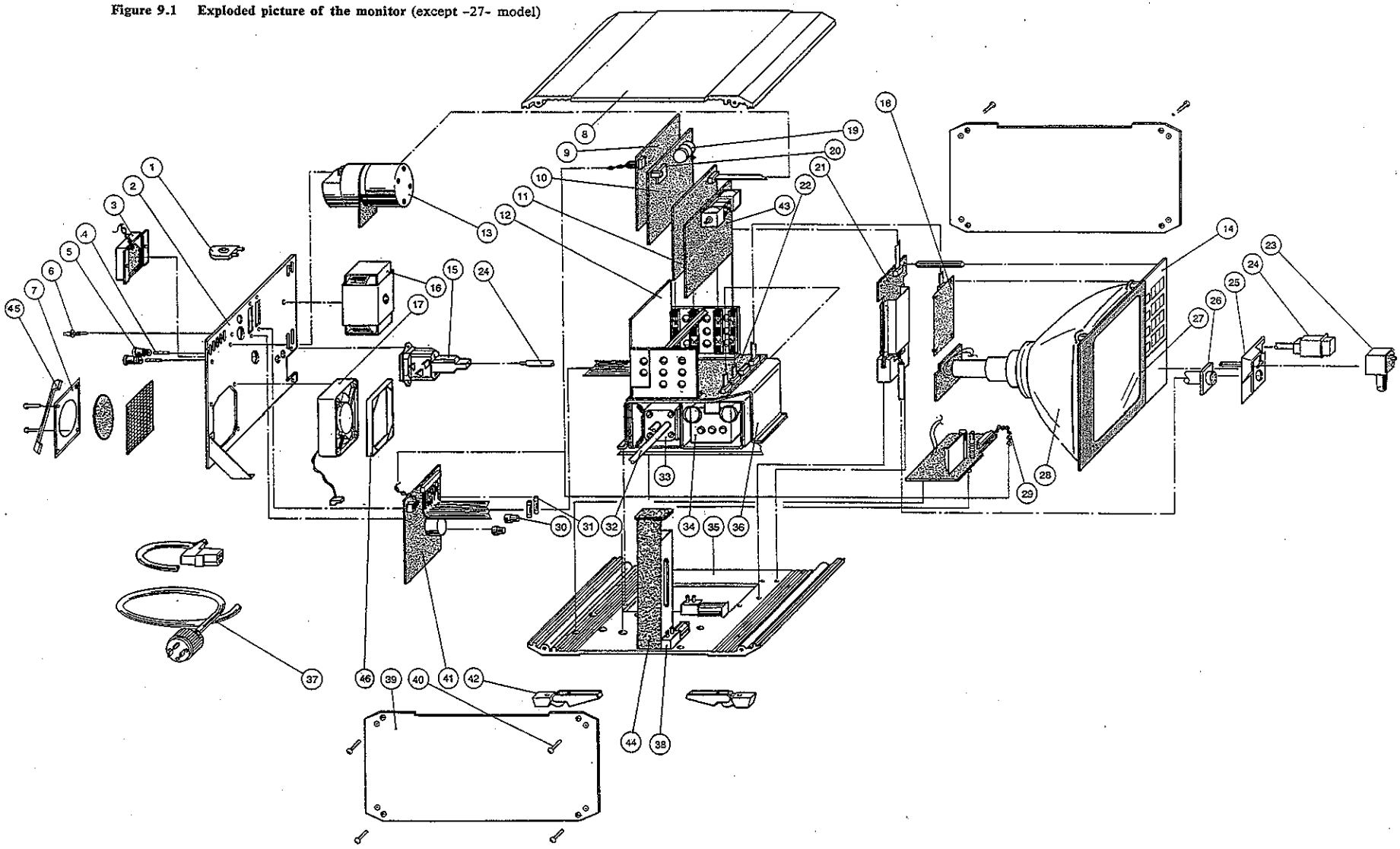


Figure 7.1 Gas sampling system adjustment chart

Figure 9.1 Exploded picture of the monitor (except -27- model)



12 APPENDICES

A COMPUTER OUTPUT (Serial & Analog I/O Connector)

In general

The output format is a string of three-digit ASCII fields separated by commas. The first field serves as a string type code field. Exception to this rule are the message strings which start with a blank followed by an ASCII string. All strings end with carriage return and linefeed characters.

Serial data strings are sent out once every 10 seconds. A numeric string of measured parameters and alarms are transmitted for data recording with a computer. The monitor's serial output has to be set to NUMERIC MODE in STARTUP/USER CONFIGURATIONS menu.

The serial communication protocol is:

- transmission rate 1200 b/s
- 8 data bits, no parity
- 1 stop bit

Normal data string starts with B00, U01, U03, or U04. Alarm activation/deactivation string starts with B99, U99, B98, or U98 and events/status string starts with B97.

Interpretation of Status Code

The 3-digit status code at the end of the serial data string indicates possible error and alarm states. Each digit must be interpreted separately according to the Table 12-1.

When the status code is 000, no status data is transmitted. When it is 100, 200, 700, or 900 no errors or alarms are active.

Serial Data String

B00-string	U01-string	U03-string	U04-string
string type	string type	string type	string type
Hours	Marker no	MV exp (l/min x 10)	EtCO2 [9]
Minutes	EtO2 (% x 10)	MV insp (l/min x 10)	FiCO2 [9]
EtCO2 (% x 10)	FiO2 (% x 10)	TV exp high (l) [3]	CO2 unit [10]
FiCO2 (% x 10)	ET balance gas	TV exp low (ml) [3]	
EtO2	Fi balance gas	TV insp high (l) [3]	
FiO2	*ASX status*	TV *insp low (ml)* [3]	
EtN2O (%)	Automatically identified gas [2]	V1.0 (%)/V0.5 (%) adults/pediatrics	
FiN2O (%)	Reserved	Compliance [4]	
EtAA (% x 100)	EtAA (primary gas, % x 10)	P peak [5]	
FiAA (% x 100)	EtAA (secondary gas % x 10)	P plat [5]	
AA selection [1]	FiAA (primary gas % x 10)	PEEP [5]	
Respiratory rate	FiAA (secondary gas % x 10)	I : E [6]	
Gas pressure (mmHg)	MAC (x 10)	Reserved	
Recorder output	Pulse rate	Reserved	
Status	SpO2	Reserved	
	IRED ampl.	Reserved	
	RED ampl.	Recorder output [7]	
	Gain	Units status [8]	
	Status	Status	

See Notes on the following page.

U03-string is available only if V-option is installed.

NOTES

1) ENF, ISO, HAL, DES or SEV. Three blanks when no agent is selected. Manual selection overrides the automatic selection.

2) ,XYZ,

X: - = No identification
H, E, I, D, or S = Identified gas (Halothane, Enflurane, Isoflurane, Desflurane, or Sevoflurane)
F = Freon (Calibration gas)
M = Mixture

Y: In case of mixture (first digit is M), second digit is H, E, I, D, S, or F according to primary identified gas in mixture. In other cases the second digit is -.

Z: As second digit, but this represents secondary identified gas in mixture.

3) TV total (ml) = (TV high x 1000) + TV low

4) For adults: string value is the same as compliance value (ml/cmH_2O, ml/kPa, ml/mmHg, or ml/mbar).

For pediatrics: string value is 10 x compliance value for all the units (ml/cmH_2O, ml/kPa, ml/mmHg, or ml/mbar).

5) String value is the same as pressure value for units cmH_2O, mmHg, and mbar. For kPa the string value is 10 x pressure value.

6) I : E ratio is 1 : (0.1 x string value)

7) Analog output selection (at serial and analog connector)

		pin 18	**pin 13**
0 :	V' & V	flow	volume
1 :	V' & P	flow	pressure
2 :	V & P	volume	pressure

8) The first and second digit are always 0. The third digit indicates either adult or pediatric, and pressure unit.

adult	pediatric	pressure unit
0	4	cmH_2O
1	5	kPa
2	6	mmHg
3	7	mbar

9) String value is 10 x CO_2 value for units % and kPa. For mmHg the string value is the same as CO_2 value.

10) CO_2 unit: 000 = %, 001 = mmHg, 002 = kPa.

Alarm Activation / Deactivation String

When an alarm is activated or deactivated, a special string is transmitted. String code for activation messages is B99 or U99 and deactivation B98 or U98. **Note that character '.' below indicates a blank.**

Activation strings

B99,OCC	Occlusion
B99,OGC	Air Leak (Open gas circuit)
B99,APN	Apnea
B99,REB	Rebreathing
B99,AA?	Anesthetic detected in expiration but not selected by user
B99,aa?	Anesthetic detected in inspiration but not selected by user
B99,NOP	No probe
B99,PRO	Probe off
B99,PUS	Pulse search
U99,DSC	Disconnection
U99,LEA	Leak
U99,OBS	Obstruction

Deactivation strings

All activation strings are followed by deactivation strings when an alarm condition is over. The code is B98 or U98. For example:

B98,OCC	Occlusion condition over
U98,DSC	Disconnction condition over

Alarm limit violations

B99,CO2,zzz,.>.,hhh	$EtCO_2$ high
B99,CO2,zzz,.<.,lll	$EtCO_2$ low
B99,.O2,zzz,.>.,hhh	EtO_2 high
B99,.O2,zzz,.<.,lll	EtO_2 low
B99,ane,zzz,.>.,hhh	FiAA high
B99,ane,zzz,.<.,lll	FiAA low
B99,ANE,zzz,.>.,hhh	EtAA high
B99,ANE,zzz,.<.,lll	EtAA low
B99,PR.,zzz,.>.,hhh	Pulse high
B99,PR.,zzz,.<.,lll	Pulse low
B99,SAO,zzz,.>.,hhh	SAO_2 high
B99,SAO,zzz,.<.,lll	SAO_2 low

U99,MVL,zzz,.>.,hhh	MVexp high
U99,MVL,zzz,.<.,lll	MVexp low
U99,AWP,zzz,.>.,hhh	Peak high
U99,AWP,zzz,.<.,lll	Peak low
U99,EEP,zzz,.>.,hhh	PEEP high

For example:

B99,PR.,000,.<.,040	No pulse. Low limit set to 40 beats/min.
B98,iso	low or high aa-alarm limit violation no longer exist in inspiration

ANE/ane = ISO/iso,HAL/hal,ENF/enf,SEV/sev,DES/des
hhh = high limit
lll = low limit
zzz = violating value

Event/Status String

Event/Status string starts with U97.

B97,POW,Pr..882916-1.1	Monitor starts after power off. Main software code.
B97,RES,Pr..882926-1.1	Monitor starts after reset. Main software code.
B97,ZER	Zeroing gas sensor
B97,CAL	Calibrating gas sensor
B97,NOR	Back to normal operation after calibration or zeroing
B97,PRE,zzz	Ambient air pressure measured at monitor start up.

zzz = ambient air pressure [mmHg]

Message String

Message strings start with a blank. **Note that character '.' below indicates a blank.**

.CO2 zero error	Zeroing CO_2 sensor failed
..O2 zero error	Zeroing O_2 sensor failed
.N2O zero error	Zeroing N_2O sensor failed
..AA zero error	Zeroing AA sensor failed

Language interpretation

German-English:

KAL = CAL

PF. = PR.

NG? = AA?

.CO2 0-fehler = .CO2 zero error

..O2 0-fehler = ..O2 zero error

.N2O zero error = .N2O 0-fehler

..NG 0-fehler = ..AA zero error

French-English:

AH? = AA?

.Erreur zero CO2 = .CO2 zero error

..Erreur zero O2 = ..O2 zero error

.Erreur zero N2O = .N2O zero error

..Erreur zero NG = ..AA zero error

Table 12-1 Status Code Interpretation

1st digit = 1, and

Status	2nd digit: 0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
No error	•															
Rebreathing alarm		•		•		•		•		•		•		•		•
Apnea alarm			•	•			•	•			•	•			•	•
Air leak					•	•	•	•					•	•	•	•
Occlusion									•	•	•	•	•	•	•	•

	3rd digit: 0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
No error	•															
CO_2 zero error		•		•		•		•		•		•		•		•
O_2 zero error			•	•			•	•			•	•			•	•
N_2O zero error					•	•	•	•					•	•	•	•
Anaesthetic zero error									•	•	•	•	•	•	•	•

1st digit = 2, and

Status	2nd digit: 0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
No alarm	•															
O_2 low alarm		•		•		•		•		•		•		•		•
O_2 high alarm			•	•			•	•			•	•			•	•
CO_2 low alarm					•	•	•	•					•	•	•	•
CO_2 high alarm									•	•	•	•	•	•	•	•

	3rd digit: 0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
No alarm	•															
Anaesthetic insp. low alarm	•			•		•		•		•		•		•		•
Anaesthetic insp. high alarm		•	•				•	•			•	•			•	•
Anaesthetic exp. low alarm					•	•	•	•					•	•	•	•
Anaesthetic exp. high alarm									•	•	•	•	•	•	•	•

1st digit = 6
(Modulation percent is given in decimal format: 02, 05, 10, 20 or 50)

Status code definition, cont

1st digit = 7											
Status	2nd digit:										
	0	1	2	3	4	5	6	7	8	9	:
Low pleth signal		•									
Pulse search			•								
Probe off					•						
No probe									•		
	3rd digit:										
	0	1	2	3	4	5	6	7	8	9	:
Pulse rate low		•				•				•	
Pulse rate high			•				•				•
SpO_2 low					•	•	•				
SpO_2 high									•	•	•

1st digit = 9											
Status	2nd digit:										
	0	1	2	3	4	5	6	7	8	9	:
MVexp low		•				•				•	
MVexp high			•				•				•
Ppeak low					•	•	•				
Ppeak high									•	•	•
	3rd digit:										
	0	1	2	3	4	5	6	7	8	9	:
Obstruction		•								•	
Disconnection			•								
Leak					•						
PEEP high									•	•	

B GRAPHICS PRINTER

CKP-124

The CKP-124 Graphics Printer is a Kodak Diconix 180si printer to be used with the DATEX-ENGSTROM monitors. Before using the printer make sure that the printer settings are as follows, see chapter Using the Printer Setup Menu in the User's guide of the printer.

(1)	Emulation	= EPSON FX-85
(2)	Page length	= 12 inches
(3)	Perforation skip	= Off
(4)	Character set	= USA
(5)	Character Default	= Set1
(6)	Carriage return	= CR
(7)	Line feed	= LF
(8)	Graphic Print Dir	= Bidirectional
(9)	LF/Graphic/Pitch mode	= Normal
(10)	Protocol	= RDY/BUSY
(11)	Parity	= None
(12)	Data length	= 8 bits
(13)	Baud Rate (Stop bits)	= 1200 (1)

CCP-104

The CCP-104 is an HP ThinkJet graphics printer. Earlier printers (CCP-104-xx-00, see the type plate on the bottom of the unit) require an isolated connecting cable (P/N 873152) to satisfy medical electronics safety requirements. Newer printers (CCP-104-xx-01) are IEC 601-1 class II devices and do not require an isolated cable. The non-isolated connecting cable is P/N 875370. Due to changes in printer cable connector design the isolated cable P/N 873152 can not be connected to the new printers.

For troubleshooting the printer please refer to the HP ThinkJet service manual. For troubleshooting the isolated connecting cable please refer to the schematics and layout of the isolation box in Figures B.1 and B.2.

PBJ-124

The PBJ-124 Graphics Printer is a Canon BJ-30 printer to be used with the DATEX-ENGSTROM monitors. Note that the printer has a Parallel Centronics interface and requires Printer Cable CC-SPC for connecting to the serial port of the monitors.

When using PBJ-124 the printer selection in User Configuration menu must be "IBM-PRO". The selection is available in main softwares of level -4.0 and up.

For the Printer Setup see Ultima Operator's Manual.

Figure B.1 Schematics of the isolation box (board modification level 1 and higher)

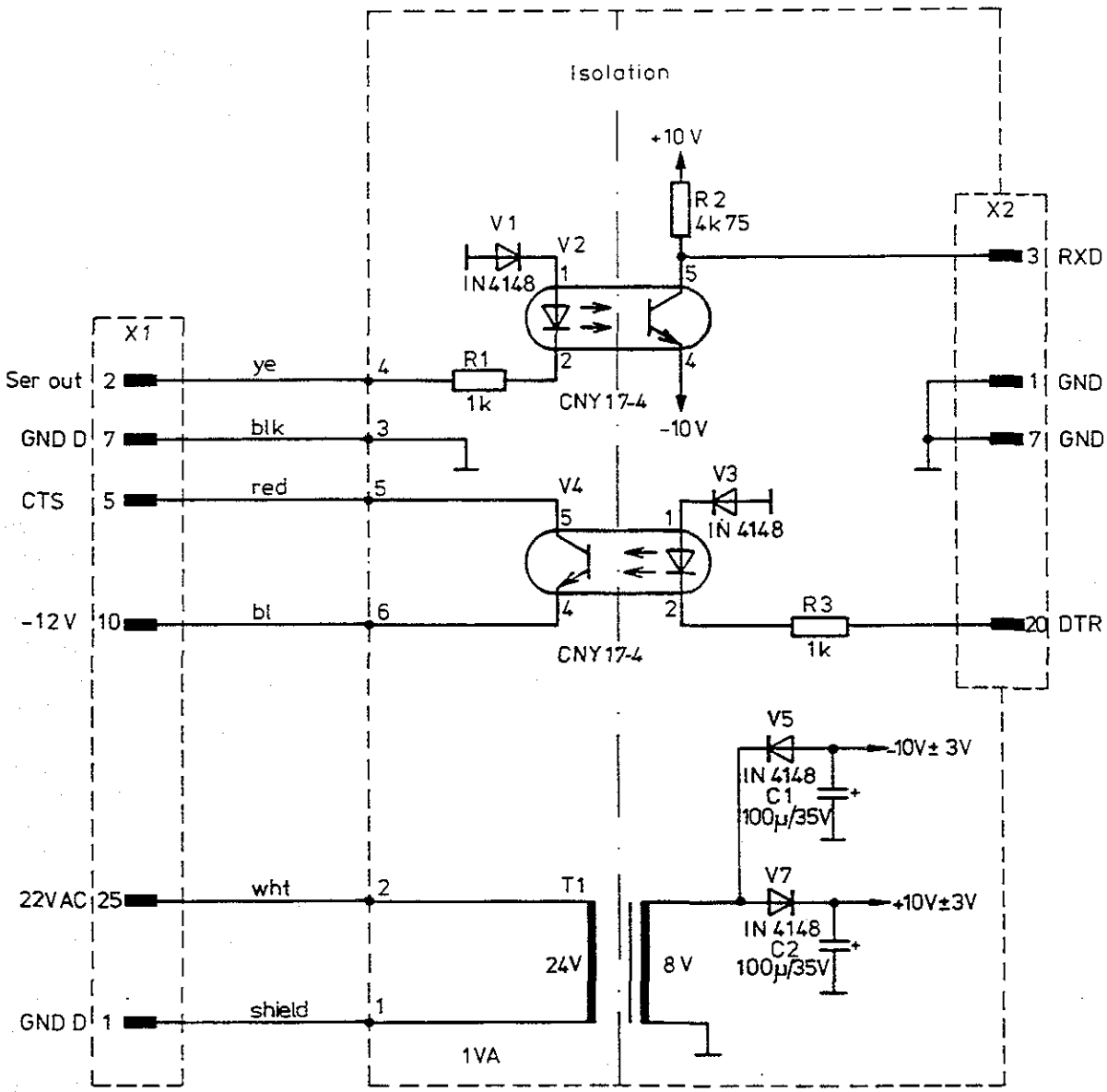
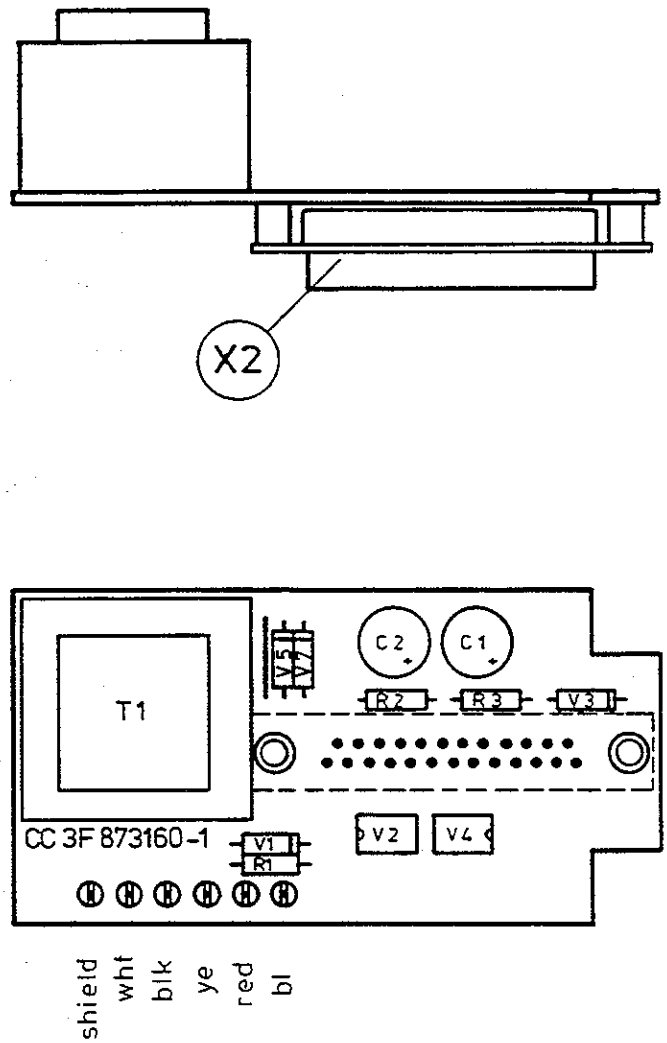


Figure B.2 Layout and assembly of the isolation box (board modification level 1 and higher)



C TRILINGUAL LIST OF ERROR MESSAGES

English	French	German
AIR LEAK	FUITE D'AIR	SYSTEM OFFEN
OCCLUSION	OCCLUSION	VERSTOPFUNG
APNEA	APNEE	APNOE
FiO2 < 18%	FiO2 < 18%	FiO2 < 18%
FiN2O > 82%	FiN2O > 82%	FiN2O > 82%
FiO2 LOW	FiO2 BASSE	FiO2 TIEF
FiO2 HIGH	FiO2 HAUTE	FiO2 HOCH
EtCO2 HIGH	ETCO2 HAUT	EtCO2 HOCH
EtCO2 LOW	ETCO2 BAS	EtCO2 TIEF
REBREATHING	REINHALATION	RUECKATMUNG
EtAA HIGH	EtAH HAUT	EtNG HOCH
EtAA LOW	EtAH BAS	EtNG TIEF
FiAA HIGH	FiAH HAUTE	FiNG HOCH
FiAA LOW	FiAH BASSE	FiNG TIEF
EtAA > 3 MAC	EtAH > 3 MAC	EtNG > 3 MAC
SELECT AGENT	SELECT. AGENT	GAS WAEHLEN
xx SELECTED	xx SELECT.	xx GEWAEHLT
ALC DETECTED	ALC. DETECTE	ALKO. ERKANNT
MIXED AGENT	MELANGE AH	NG-GEMISCH
UNKNOWN AGENT	AGENT INCONNU	NG UNBEKANNT
CALIBR. GAS DETECTED	GAZ ETALON DETECTE	KALIBR.-GAS ERKANNT

RR LOW	FR BASSE	RF TIEF
RR HIGH	FR HAUTE	RF HOCH
REPLACE TRAP	REMPL. D-FEND	D-FEND ERNEU.
Ppeak HIGH	PImax HAUTE	Ppeak HOCH
Ppeak LOW	PImax BASSE	Ppeak TIEF
PEEP HIGH	PEP HAUTE	PEEP HOCH
MVexp HIGH	VMexp HAUT	MVexp HOCH
MVexp LOW	VMexp BAS	MVexp TIEF
MEMORY CHIP FAILURE	ERREUR CHIP MEMOIRE	SPEICHER-CHIP FEHLERERREUR
ROM CHECKSUM ERROR FEHLER	ERREUR DE ROM	ROM CHECKSUM
PULSE SEARCH	RECHER. POULS	PULS SUCHE
NO PULSE	PAS DE POULS	KEIN PULS
NO PROBE	PAS DE CAPTEUR	KEIN SENSOR
PROBE OFF	CAPTEUR DECONN.	SENSOR LOSE
LOW PLETH SIGNAL	SIGNAL PLETH PEU FIABLE	GERINGES PLETH-SIGNAL
CHECK PROBE	VERIF. CAPTEUR	CHECK SENSOR
SpO2 HIGH	SpO2 HAUTE	SpO2 HOCH
SpO2 LOW	SpO2 BASSE	SpO2 TIEF
PR HIGH	FP HAUTE	PF HOCH
PR LOW	FP BASSE	PF TIEF
SpO2 ARTIFACT	ARTEFACT SpO2	SpO2 ARTEFAKT

Leak	Fuite	Leck
Disconn	Deconn.	Diskonn
Obstr	Obstr.	Obstr